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Vol. II

TRANSCRIPT OF RECORD

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Supreme Court of the United States

OCTOBER TERM, 1940

No. 666

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DETROLA RADIO AND TELEVISION CORPORA-  
TION, PETITIONER,

vs.

HAZELTINE CORPORATION

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ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT  
OF APPEALS FOR THE SIXTH CIRCUIT

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PETITION FOR CERTIORARI FILED DECEMBER 31, 1940.

/ CERTIORARI GRANTED FEBRUARY 3, 1941.



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Continuation of testimony of Virgil M. Graham  
(part of Plaintiff's Exhibit '26), stipulated from Dela-  
ware case (R.C.A. v. Hazeltine).

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Q18 Will you look at that set, Mr. Graham, and tell me whether that is one of the standard 601 Stromberg-Carlson sets?

A No, it is not a standard set. I see several pieces of apparatus have been added.

Q19 Will you tell us what changes are apparent in that set, from inspection?

A Two resistors and a condenser were added to the audic panel, and some apparatus added to the first audio stage, the first radio stage, I should say, so that the shields would not fit the place.

Q20 In other words, I see in the set three metal cans, and then in one place, some apparatus without one of those metal cans; is that what you mean by the shield not being in place?

A Yes, sir, there should be another can similar to those.

Q21 Over what?

A Over this whole assembly here.

Q22 And what makes it impossible for that—

A This piece of apparatus.

Q23 What is that apparatus sticking out?

A Apparently it is a by-pass capacity.

Q24 What was the other change that you mentioned in the set?

A Two resistors were added there.

The Court: Where are the resistors?

The Witness: Here (indicating).

Q25 What do they look like?

A Small tube resistors, without the Bakelite capacitor,

The Court: Where is the capacitor?

The Witness: Here (indicating).

Q26 For the record, we might define the location.

The Court: Certainly.

Q27 Are these resistors conspicuous in the set because of their color?

A No.

Q28 The way they are right now, can you describe them to us, by pointing out what color they are?

The Court: Are they the red streaks?

A They are two tubular objects with red labels on them.

Q29 And the capacitor to which you refer, is placed between them?

A Yes; it is a brown Bakelite unit.

Q30 Can you tell us what is the circuit of that set, as modified, Mr. Graham?

A No, I can not.

Q31 Do you know what happened to this set after it was built by the Stromberg-Carlson Company?

A By again refreshing my memory from the diary, it was shipped on Thursday, August 5, 1926, to Mr. Wheeler at the Hazeltine Laboratories in Hoboken.

Q32 What is there in your diary that refreshes your recollection on that?

A An entry under that date stating "Shipped Audiostat set to Wheeler."

Q33 Was the Stromberg-Carlson Telephone Manufacturing Company, a licensee of Hazeltine Corporation at that time?

A Yes, sir, it was.

Q34 Were there other companies that were licensees of the Hazeltine Corporation at the same time?

A Yes, sir.

Q35 Did those companies or their engineers have meetings from time to time to discuss radio problems?

A Yes, sir, they did.

Q36 Do you know whether this Wheeler Audiostat invention was disclosed to the engineers associated with the Hazeltine licensees in 1926?

A My recollection is not clear on that point.

Q37 I have here two mimeographed sheets entitled, "Minutes of August meeting of the I.R.M. Engineers." Can you identify that?

A Yes, sir, they are minutes which I wrote, as Secretary of that group.

Q38 You were Secretary of that group in 1926?

A Yes, sir.

Mr. Adams: Would your Honor like a copy?  
(Handing)

Q39 On page 2, I notice a list of names of individuals, and a list of names of companies following a statement, "Those present at the meeting were—"; Can you tell me who those people were generally, were they representatives of those companies?

A They were in general, the Chief Engineers or Radio Engineers of those companies.

Q40 I notice that in these minutes it states:

"Mr. MacDonald further reported",

and then it goes on with some statement, and then in the next paragraph it says:

"He also reported that last summer, Mr. Wheeler had suggested an automatic volume control whose function was to keep the signal at the detector down to a certain level. This device had been called the Audiostat. A model had been prepared and was on exhibit at the laboratory. This device overcomes some of the greatest disadvantages of receivers."

Do you know what model that is, that is referred to there?

A Yes; it referred to the model prepared by the Stromberg-Carlson Laboratory.

The Court: The one here?

The Witness: Yes, sir.



Q41 Do you know what laboratory is referred to in that statement?

A The Hazeltine Laboratory.

Q42 Later on, I notice at the foot of the page, the statement:

"Mr. Wheeler then described, in detail the function and construction of the Audiostat. This device works by controlling the amplification of the radio amplifier tubes by varying the grid bias, which in turn is controlled by the strength of the signal at the detector."

Was that disclosed at that time by Mr. Wheeler?

A My recollection is not clear, but my minutes state so, and I know that these minutes were written or taken down at the time of the meeting.

Q43 And they were correct at the time that you wrote them?

A They were.

Q44 In the portion that I previously referred to it states: "This device overcomes some of the greatest disadvantages of receivers." Is that a statement of the impression that this made on you at that time?

A Yes, it was.

Q45 What were these disadvantages to which you refer?

A The variation of sound output from the loudspeaker with different signal strengths on the antenna and the results of fading.

The Court: Will you repeat that answer?

The Witness: The variation of sound output from the loudspeaker with different signal strengths on the antenna from different stations with varying distances or varying powers and the results of fading.

Q46 In other words, one of the disadvantages was the effect of fading, as I understand it?

A That is right.

Q47 You mentioned another disadvantage. Would that be what we refer to as "blasting" as you tuned from station to station?

A That would be one effect, yes.

Q48 When did the Stromberg-Carlson Company build its first set using automatic volume control that was marketed commercially?

A To the best of my recollection it was 1929.

Q49 Were you at that time a licensee of the Hazeltine Corporation?

A Yes, sir.

Q50 That is, was the Stromberg-Carlson Company a licensee of the Hazeltine Corporation?

A Yes, sir.

Q51 Was the Stromberg-Carlson Company at that time also a licensee of the Radio Frequency Laboratories?

A Yes, to the best of my recollection.

Q52 What was the organization known as the Radio Frequency Laboratories?

A It was a group of research engineers having some of the best men in the industry engaged in developing a patent situation and working up new circuit devices.

Q53 When you built your first commercial automatic volume control set, did you design the whole thing in your own organization?

A No, it was a Radio Frequency Laboratory design, the fundamental design.

Q54 Was that their business, to furnish designs to the company for the manufacture of sets?

A Yes.

Q55 Was the whole thing designed by the Radio Frequency Laboratories as a complete set?



A The fundamental circuit design for the complete set was provided by them, and the Stromberg Laboratories did the necessary design work to put it in shape for production.

Q56. Was the automatic volume control system in that set designed by the Radio Frequency Laboratories?

A Yes, sir, it was.

Q57 Was that automatic volume control system in that set what is known as a diode automatic volume control system?

A No, sir, it was a triode.

Q58 For how long did the Stromberg-Carlson Company continue building commercially sets employing the triode type of automatic volume control?

A Approximately two years.

Q59 Did you then change the type of automatic volume control system that you employed?

A Yes.

Q60 To what did you change it?

A The diode type.

Q61 On whose recommendation was that?

A That was also based on R.F.L. designs.

Q62 And when you say "R.F.L." you mean Radio Frequency Laboratories?

A Yes.

Q63 Did the Stromberg-Carlson Company during the time you were with it, which I understand was up to the end of 1935, ever change from the diode form of automatic volume control?

A No, it did not.

Q64 During the time that you used the triode form of automatic volume control, did you ever have any difficulties with that form of automatic volume control which were inherent in the system itself?

A We had difficulty with the characteristics of the so-called automatic volume control tube.

Q65 What do you mean by that? Will you explain it a little further?

A The plate current had to be held to very close limits in order that the set functioned satisfactorily. If the plate current ran too high, the sensitivity of the receiver was reduced; and if it was too low the control did not function as well.

Q66 What was the practical effect of that on the manufacturer or the user?

A It meant from the standpoint of the manufacturer that we had to select tubes.

Q67 What do you mean by that?

A We had to pick tubes especially for the automatic volume control tube socket.

Q68 Does that mean that you would ship the tube with the set?

A Yes. I would not say that, but my recollection is that we labelled tubes for those sockets.

Q69 Suppose something happened to the tube, what would the user do?

A He would have to undoubtedly try several replacement tubes until he found one that worked satisfactorily.

Q70 Did you ever have any trouble with your automatic volume control system which employed the diode where the trouble was inherent in the diode system itself?

A Nothing that could not be corrected by design.

Q71 In that are you distinguishing from the difficulties you had with the triode system?

A Yes, in the case of the triode system we were depending on the skill of the tube manufacturer in making tubes to close limits.

Q72 Did the skill of the tube manufacturer at that time seem to be equal to the task of making them so that it was commercially possible to place the set in the hands of the user so that he could change tubes if he had to?

A My recollection was that it was not, and the tubes had to be selected.

Mr. Adams: I would like to offer in evidence a copy of the minutes of the August meeting of the I.R.M. Engineers.

Mr. Philbin: No objection.

(Received in evidence and marked "Plaintiffs' Exhibit No. 13".)

By Mr. Adams:

Q73 Before you leave that, can you more definitely identify the various engineers of the companies listed on page 2 in those minutes?

A In what way do you mean?

Q74 Who was Mr. Binns of the Hazeltine Corporation? Was he an engineer of the Hazeltine Corporation?

A No, he was a representative of the Hazeltine Corporation attending a number of these meetings, as I recollect it.

The Court: Was he an engineer?

The Witness: No, he was not an engineer.

The Court: A salesman?

The Witness: An executive would be a better term, your Honor.

Q75 Was Mr. Clement an engineer with the F.A.D. Andrea, Inc.?

A Yes, he was Chief Engineer, I believe, at the time.

Q76 And was H. Dreyer an engineer with Freed Eismann Radio Corporation?

A Yes, sir.

Q77 And the next one on the list is Mr. Graham, and I assume that was yourself?

A That is right.

Q78 Then there is a Mr. Johnson of the Hazeltine Corporation. Was he an engineer of the Hazeltine Corporation?



A Yes, sir, he was.

Q79 And Mr. Loeser, was he an engineer of the Eagle Radio Company?

A Yes, sir.

Q80 And Mr. MacDonald of the Hazeltine Corporation, was he an engineer?

A Yes, sir.

Q81 And Mr. Manson of the Stromberg-Carlson Telephone Manufacturing Company?

A Chief Engineer of Stromberg-Carlson.

Q82 Who was Mr. Marsten?

A An engineer of the Freed-Eisemann Radio Corporation.

Q83 And Mr. Miessner?

A An engineer with the Garod Corporation.

Q84 And Mr. Million?

A Chief Engineer for King-Hinners Radio Corporation.

Q85 And Mr. Russ?

A He was General Manager of the Independent Radio Manufacturers, Inc.

Q86 And was that a corporation the stock of which was owned by these associated manufacturers?

A I believe so, although I do not have any recollection about that.

Q87 Who is Mr. Tyzzer?

A An engineer with the Amrad Corporation.

Q88 And Mr. Wheeler?

A An engineer of the Hazeltine Corporation.

Mr. Adams: I will offer in evidence the Stromberg-Carlson set which has been referred to by the witness.

Mr. Philbin: No objection.

(Received in evidence and marked "Plaintiffs' Exhibit No. 14.")

The Court: What are these last minutes to which you made reference?

Mr. Adams: Those are the same minutes to which I previously made reference and of which you have a copy. That is all.

*Cross Examination*

By Mr. Philbin:

XQ89 Referring to the set Plaintiffs' Exhibit 14, do you remember whether any circuit diagram of the set with the additions that you spoke about was made by the Stromberg-Carlson Company before it was shipped by you in 1926?

A Yes, I believe there was an entry made in a notebook.

XQ90 Was there any circuit diagram or schematic diagram of the circuits and what was in the set made at that time by the Stromberg-Carlson Company?

A The original diagram from which the set was made was provided by Mr. Wheeler.

XQ91 And do you know where that is now?

A No, sir, I do not.

XQ92 May I see the notebook to which you refer?

A Yes, sir.

XQ93 You are now showing me four loose-leaf sheets. Are those all that you were speaking of as the notebook in your testimony?

Mr. Davis: The diary he called it.

A Do you mean were there more sheets?

XQ94 Yes.

A Yes.

XQ95 Have you those sheets here?

A No, sir, I have not.

XQ96 I find on the page dated August and under the date of Thursday, the 5th, the following:

"Audiostat tried out. Meter in plate circuit of first radio tube indicated that it worked properly. Called Wheeler. He said he was sending design data on coils to Levy. Shipped Audiostat set to Wheeler."

Do you find any other reference to this so-called Audiostat or any description of what the Audiostat was in these pages from your diary?

A There is one other reference that another set was built at a later date.

XQ97 Is that reference under date of August 18th as follows:

"New Audiostat set completed. Set with antenna coupling tube made, very good."

A Yes, that second line is not apropos of the first note.

XQ98 But is there any description in these diary pages of what this Audiostat was?

A In making this diary I made no effort to go into detail.

XQ99 Have you any recollection at this time of what this new device was which you said was told you by Wheeler in August, 1926?

A It was a circuit to control the gain of the R.F. tubes, in accordance with the signal at the detector, so that the signal stayed substantially constant at the detector.

XQ100 Are you a radio engineer?

A Yes.

XQ101 Were you in 1926?

A Yes, sir.

XQ102 Did you have anything to do with the designing and development of Stromberg-Carlson radio circuits in 1926?

A Yes, sir.



XQ103 Can you tell us by what means this result you have spoken of was to be accomplished by this Audiostat arrangement, that is, what kind of circuits and what kind of tubes or what kind of resistances?

A My recollection of the circuit details are very, very vague.

XQ104 Do you remember whether Mr. Wheeler told you to use a diode or a triode for a detector?

A Not in so many words. I do not recollect that that was mentioned. He gave us the circuit and we built it accordingly.

XQ105 Then at the present time you have no recollection whatsoever as to the particular details or the parts of this new so-called Audiostat circuit?

A Nothing that I can tie back definitely to that set.

XQ106 In these minutes, Plaintiffs' Exhibit 13, of August, 1926, there is a statement that you heard a description of this Audiostat. Can you remember now what that description was?

A Nothing more than what the minutes bring back to my memory as stated in the minutes.

XQ107 Were you not interested in any new development in the radio circuits which might be usefully employed in the broadcast sets made by the Stromberg-Carlson Company in 1926?

A Yes, sir, I was very much interested in this particular device.

XQ108 Do you not think that you would be apt to remember at least generally what kind of a device it was if it really seemed new or important to you?

A Only from its general characteristics.

XQ109 Will you tell me some more of what you did as a radio engineer with Stromberg-Carlson. Did you design coils and condensers or did you just have a general supervision and not go into the details of the circuits in 1926?

A It was partially both. I had general supervision of the working up of the production designs and I did a certain amount of the actual laboratory work.

XQ110 And you do not remember now how this new Audiostat arrangement worked as told you by Mr. Wheeler at the Stromberg-Carlson plant and later at the meeting in August, 1926?

A In so far as the general characteristics as mentioned in these minutes, that it functioned by controlling the gain of the R.F. tubes.

XQ111 But you do not recall the way in which the functioning was carried out?

A Not the circuit details.

XQ112 This Audiostat arrangement was explained to you, as I understood your statement, in August, 1926. When did the Stromberg-Carlson Company first put out a set commercially containing automatic volume control?

A According to my recollection it was 1929.

XQ113 That is about three years later?

A About two and a half would be more accurate.

XQ114 Can you tell us why the Stromberg-Carlson Company did not use any automatic volume control before 1929?

A It was a matter of executive decision.

XQ115 You did not have anything to do with that?

A No.

XQ116 Was your advice then asked as an engineer as to whether what Mr. Wheeler told you was desirable to be put into the Stromberg-Carlson sets?

A My only recollection is that the device was discussed several times, in line with the preparation of the following year's models, but I do not remember why the decision was not to use it.

XQ117 Was the Stromberg-Carlson Company a licensee of Hazeltine Corporation during the years 1926 to 1934?

A Yes, sir.

XQ118 Did you ever recommend to the executives that this audiostat arrangement should be used?

A I do not recollect the exact proceedings at these conferences. I remember stating that it functioned satisfactorily.

XQ119 Now, you said that in the first Stromberg-Carlson set employing automatic volume control, which was put out in 1929, the automatic volume control detector was of the 3-electrode or triode type. Will you tell us whether or not screen grid tubes were used as amplifiers in that set?

A Yes, sir, I believe they were.

XQ120 Then the diode type of A.V.C. rectifier was used, as I understood you, in 1931?

A Approximately two years later, that is correct.

XQ121 When the diode type was used, did the amplifier tubes have both the screen grid characteristic and also the variable Mu characteristic?

A I believe so.

XQ122 And has it not been true that whenever Stromberg-Carlson has put out an A.V.C. set with a diode operating as the A.V.C. rectifier, the amplifier tubes have been of the variable Mu variety?

A Yes, variable Mu tubes were used from their first commercial introduction.

XQ123 Was that about the summer of 1931?

A That is my recollection.

XQ124 When the Stromberg-Carlson Company put out its first A.V.C. diode set in 1931, was a single diode rectifier used for both the A.V.C. controlling voltage, and also for producing the audio frequency currents.

A No, sir. A triode was used as a double diode, the grid being one diode, the plate being the other.

XQ125 That is, a triode connected as a diode, was



used both for A.V.C. and for audio frequency detection?

A The question is not quite clear, sir.

XQ126 In this diode detector that was used in 1931, and which was connected as a diode, was there any detector to produce audio frequency currents other than the detector which produced the A.V.C. potential?

A Well, the grid, as I remember it, used as the one diode anode, produced the audio, and the plate as the diode anode, produced A.V.C.

XQ127 The one tube was used to do two things?

A That is right.

XQ128 In 1932, did you use one tube for those two things, or did you use separate diodes?

A My recollection is we used the same circuit, but our function could have been performed by two separate diodes. It was merely using a triode as two diodes.

XQ129 You speak of a triode connected as a diode; is there any difference between a triode connected as a diode and an ordinary diode?

A No; not in general, no.

XQ130 What do you mean, "in general"?

A You may have minor differences and characteristics.

XQ131 But generally, the characteristics, the differences, are not of a major importance in the operation of a receiver?

A No.

XQ132 In the first automatic volume control set put out commercially by the Stromberg-Carlson Company, in 1929, was there any normal or starting bias on the grids of the amplifier tubes, that is, in addition to such bias as might be contributed by the A.V.C. rectifier?

A Yes, sir; it is my recollection that the normal rated bias, or very closely that value, was applied.

XQ133 About what was that?

A I presume about three volts.

XQ134 That is about three volts on the grids of the one or two amplifier tubes that had the A.V.C. effect?

A That is right.

XQ135 Do you recall how those approximately three volts were produced?

A I believe the original source of that voltage was the negative leg in the B power supply, biasing the two diodes, and cathode, of the detector tube, so that the voltage fed through the A.V.C. line was substantially that voltage with no signals present.

XQ136 You speak of the grid bias of about three volts. What do you mean by that; three volts in relation to what?

A Three volts negative with respect to the cathode.

XQ137 To what part of the cathode, that is, to the average potential cathode, or to the most positive part of the cathode?

A The tubes had unipotential cathodes?

XQ138 So that the three volts would be with respect to all parts of the cathode, negative?

A yes.

XQ139 Now, you spoke of some difficulties that the Stromberg-Carlson Company had with the triodes when they were using them for A.V.C. rectifiers, and I understood you to say that your company had to be very careful with them, while, with the diode, those tubes were more uniform in quality, although there was a little bit more difficulty in design; is that correct, in designing the circuits for them?

A No. I may not understand your question, but what I said was that we had to, to the best of my recollection, select tubes for plate current values for that service.

XQ140 That is, the plate current values of the triodes

at that time, differed somewhat, which made it important to select the proper triode; is that it?

A The proper tube of the same type.

XQ141 Is there still that difficulty with triodes, so far as you know?

A I do not believe that the limits have been improved greatly.

XQ142 Did you use a triode as a double diode tube for the A.V.C. rectifier?

A Yes, sir.

XQ143 Will you tell us what these double diodes, that is, the two diodes in the single tube did?

A Yes; one of them was used for the automatic volume control, and the other for the detector.

Mr. Philbin: That is all.

Mr. Adams: That is all. Thank you very much.  
(Witness excused.)

#### AFTER RECESS

Mr. Adams: I would like again to ask to interrupt the defendant's case to put on two short witnesses, and I understand Mr. Philbin has no objection, if your Honor approves.

Mr. Philbin: No objection.

The Court: Very good.

MAURICE L. LEVY, was called as a witness on behalf of the plaintiff, in rebuttal, and having been first duly sworn, testified as follows:

#### *Direct Examination*

By Mr. Adams:

Q1 What is your present occupation?

A Radio Engineer.



Q2 With what company?

A Stromberg-Carlson Telephone Company.

Q3 What is your work as a radio engineer with the Stromberg-Carlson Telephone Company?

A Designer of radio receivers.

Q4 How long have you been with that company?

A Twelve years.

Q5 Have you been a radio engineer during that entire time?

A Yes, sir.

Q6 When did you first hear of automatic volume control in a radio receiver?

A In a discussion with Mr. Harold Wheeler at Rochester in August, 1926.

Q7 Can you place the date more accurately than August, 1926?

A Somewhere between August 4th and August 11th.

Q8 How can you place that date?

A By an insertion in my notebook.

Q9 Your notebook?

A Yes.

Q10 What sort of a notebook is that?

A A notebook that contains a record of all the work I did day by day in chronological order.

Q11 Are the pages numbered?

A The pages are numbered.

Q12 And in what order do you enter your work on these pages of your notebook?

A Chronological order. The work done today is put on one page and the work done tomorrow is put on the next page.

Q13 Where is the entry which you say establishes when Wheeler disclosed to you the automatic volume control system, on what page?

A Page 59.

Mr. Adams: I am sorry I have no copies of this, your Honor.

Q14 Is that page dated?

A That page is not dated.

Q15 What is there in the book that enables you to place the date?

A On page 60 I have a date of August 11, 1926, and on page 58 I have a date of August 4, 1926.

Q16 Did you place those dates in the book?

A Yes, sir.

Q17 When did you place those dates in the book?

A On those dates.

Q18 Were those entries made in the regular course of your work as a radio engineer with the Stromberg-Carlson Company?

A That is right.

Q19 Do you know them to be correct?

A Yes.

Q20 And do I understand that that leads you to conclude that the entry on page 59 was made somewhere between those two dates?

A Yes, sir.

Q21 What is disclosed on that page 59 of your notebook?

Mr. Philbin: Objection, your Honor.

The Court: The page would disclose what it discloses.

Mr. Adams: I can get at it in another way.

Q22 I understand you to say that Mr. Wheeler disclosed to you at this time an automatic volume control system, is that right?

A Yes, sir.

Q23 Did you make a record at the time of the system that he disclosed to you?

A This insertion in my notebook on page 59 is the record I made.

Q24 Of what?

A Of the automatic volume control circuit.

Q25 Can you describe for us the automatic volume control system which is disclosed on that page of your notebook?

A Yes, sir.

Q26 In what form is it shown, is it written out or is it a circuit diagram?

A It is shown in a schematic circuit diagram.

Q27 How many tubes are shown?

A Three.

Q28 What are those three tubes?

A The first tube is the amplifier tube in the antenna stage; the second tube is the diode detector tube and the third tube is an audio amplifier tube.

Q29 What is the function of the first tube?

A The first tube is to amplify the radio-frequency signals coming in on the antenna.

Q30 What is the function of the diode detector tube?

A That is to rectify the carrier, produce audio-modulation for audio amplification and also provide automatic volume control voltage which is fed back to the antenna stage amplifier tube.

Q31 And what is the function of the third tube?

A The third tube amplifies the rectified audio to a level necessary to reproduce in a loud speaker or head set.

Q32 I notice in that entry there seems to be a blank space between the first tube and the next tube. Does that indicate anything?

A It just indicates that the diode does not function on any part of the circuit except that which is shown on the page, that is, the diode feeds back only to this one tube in this particular insertion.



Q33 In building a circuit of that kind would there be anything inserted in that blank space?

A You mean if the circuit were completed to be used in a radio receiver?

Q34 That is right.

A Yes, there would be another transformer and another tube.

Q35 Is there any indication in that circuit on that page of a visual tuning indicator?

A Yes, there is an indication of a meter being placed in the plate circuit of the antenna stage amplifier tube. It is marked with an arrow and marked "MA."

Q36 Is the detector stage labelled in this diagram?

A Yes.

Q37 How is it labelled?

A Directly over the tuned circuit is marked "ANT-Stage."

Q38 Is the detector stage labelled in this diagram?

A Yes.

Q39 How?

A In the same manner. We merely write or print "detector-stage" under that particular portion of the circuit which is the detector stage.

Q40 I asked first about the detector stage, and I will now ask you is the amplifier stage labelled? I think you have already answered it by saying that one of the stages is labelled that way. Is the stage which is labelled "Ant-stage" the amplifier stage?

A Yes, sir.

Q41 Did you ever build a set using that automatic volume control system?

A Yes, sir, I did.

Q42 When did you build that?

A I built that some time in August.

Q43 Of what year?

A 1926.

Q44 What steps did you actually take to build it?

A We used one of our standard receivers, our Model 601-B and revised it and included the circuit in that particular receiver corresponding to the circuit in this notebook.

Q45 You say you revised it. Does it mean that you made changes in an actual standard set?

A That is right.

Q46 I show you a set which has been offered in evidence here as Plaintiffs' Exhibit 14 and ask you if you can identify that?

A Yes, I think I can.

Q47 What is it?

A 601-B receiver.

Q48 Stromberg-Carlson?

A Yes.

Q49 Of the type which you say was modified to include the automatic volume control system of Wheeler?

A That is right.

Q50 Can you further identify it and tell me whether that is the one that you did modify at that time?

A It is the one. That particular set was inscribed with my initials and a number of others.

Q51 Will you examine this and see if you can find those initials?

A My initials "M.L.L." are inscribed on this panel.

Q52 Where is that panel in the set?

A That panel is made up of a number of parts including the audio-transformer and a couple of tubes.

Mr. Adams: It is rather difficult to see those initials. I have here some photographs of that part of the set which I could get the witness to identify to make it easier for the purpose of record.

The Court: Any objection?

Mr. Philbin: No objection.

By Mr. Adams:

Q53 I show you a photograph and ask you if that is a photograph of that portion of the Stromberg-Carlson set, Plaintiffs' Exhibit 14, to which you have just pointed as showing your initials M.L.L.?

A Yes, it is.

Mr. Adams: I offer it in evidence as Plaintiffs' Exhibit 15.

Mr. Philbin: No objection.

(Received in evidence and marked "Plaintiffs' Exhibit No. 15.")

By Mr. Adams:

Q54 Under what circumstances were those initials placed on there?

A The set was built in Rochester and shipped to the Hazeltine Corporation at which time I was present, along with some other people, and operated the radio receiver at the Hazeltine Corporation Laboratories, which were then at Hoboken, I think, and we operated the radio receiver and it was there that we inscribed our initials.

Q55 When you say "we" who do you mean?

A I remember Harold Wheeler was there and a fellow by the name of Johnston.

Q56 Do you find those initials on the set at the present time?

A Harold Wheeler's initials are there.

Q57 What are they as shown thereon?

A "H.W." I can make out the H.W. but I cannot make out the middle initial, or I cannot read it.

Q58 You cannot understand what it is?

A That is right. I can understand the H and the W, and this is W.A.M., William A. MacDonald.

Q59 Was he present at that time?

A I do not remember whether he put it on there



while I was there, but I know that Harold Wheeler and I inscribed it at the same time.

Q60 I notice there is also inscribed in the set the date "August 11, 1926." Was that date on the set at the time that you put your initials there?

A Yes, sir.

Q61 Was that date the date on which you put your initials there?

A Yes, sir.

Q62 Was the set demonstrated on that date?

A Yes.

Q63 Was it successful?

A Yes.

Q64 Did the automatic volume control system operate successfully?

A Yes, sir, it did.

Q65 Do you know whether this actual set, Plaintiffs' Exhibit 14, embodies the Wheeler automatic volume control system that is shown in your notebook on page 59?

A Yes, sir, it does.

Q66 You have checked that recently?

A Some time back, and I do not remember when.

Q67 Can you point out the parts that distinguish this set from your regular 601-B standard model?

A Yes, sir.

Q68 Will you do so?

A This is the detector stage and this corresponds with the—

Q69 For the purposes of the record, instead of "this" I wish you would describe what you are pointing to. Describe it by locating it with reference to the front panel or something of that sort?

The Court: Is this a repetition of what we had yesterday?

Mr. Adams: It is in substance. Again I might

suggest that it would probably be more convenient for your Honor and for the purpose of the record to have these things marked on the photograph rather than to point to them in the set.

The Court: No objection, Mr. Philbin?

Mr. Philbin: No objection.

Q70 I hand you a photograph and ask you if that is a photograph of this set, Plaintiffs' Exhibit 14?

A Yes, it is.

Q71 Will you indicate on that photograph by actually placing ink marks on it, the changes which were made that converted this set from your standard 601-B set to the modified set employing Wheeler's system of automatic volume control?

A The metal shield is off and the apparatus is under that shield. It is under that shield there which is not uncovered, and I can do a partial identification. The apparatus is in the back shield rather than in the middle.

Q72 Then the photograph will not be helpful. Describe the apparatus itself as well as you can.

A The input to the diode or the tuned circuit feeding the diode consists of this round coil form of black material about three inches in diameter, whose terminals feed into this condenser which consists of these brass plates, one set of which were stationary and the other are movable.

Q73 There are a number of such in the set. Will you locate the ones that you are referring to?

A This variable condenser is the one in the extreme rear of the chassis.

Q74 From the panel?

A From the panel back. One side of that condenser ties to ground which is the base, and the other side connects to the trimming capacitor which is a brown Bakelite strip, two inches long, in the upper righthand corner of the rear compartment.

That feeds into two capacitors in series which correspond with the single capacitor approximately 100 micros feeding through a grid leak resistance, which has this glass enclosed rod with a red label on it.

Q75 Is that rod with the red label something that was standard or was that added?

A That was added.

Q76 Was this condenser added that you have spoken about, this brass condenser?

A This brass condenser was standard equipment.

Q77 And the black coil is standard?

A Yes.

Q78 Just make it clear as we go along. I want the things that you added.

A These brown capacitors, about an inch or an inch and a half, which are electrically connected in series were added, and they appear in the lefthand corner of the rear panel.

Q79 Let me interrupt, I show you a notebook, page 75. Can you identify this?

A Yes, that is a circuit drawn by Harold Wheeler which I witnessed on August 11, 1926.

Q80 Does that show the circuit of this particular receiver?

A Yes.

Q81 Does that help you in tracing through the connections in this receiver?

A Yes, that would help a lot.

Q82 In tracing through the connections you can refer either to that or to your original notebook?

A It will not make any difference.

Q83 Proceed.

A The rod, enclosed in a glass case as a resistor with a red label, ties into the diode tube. This tube is really a triode operated as a diode with two elements



tied together to operate as one. The A.V.C. feed is another resistor which is wired back to the amplifier stage through a wire coming off the bottom of this other glass enclosed resistor. There is a .006 condenser which is another piece of this Bakelite apparatus which feeds into the amplifier tube. The audio amplifier tube with its associated resistors of the same type as the others returns the bias to ground to complete the electrical circuit.

Q84 Were there any other changes made?

A There was one audio transformer on here and another audio transformer on this panel which is standard equipment which was removed in order to make these changes.

Q85 I notice that the stage which is in the front left of the set, viewing it from the front of the panel, has no shielding can. Is that standard?

A Yes. There were four shielding cans to make that standard.

Q86 Did you remove one of the shielding cans in order to make this change?

A No.

Q87 I point to an electrical part of the stage I have just referred to, and ask what that is?

A This was a blocking condenser to return the R.F. circuits to ground through the condenser to provide a D.C. path through the R.F. coil which is this black tubing up to the grid, whose function is to carry the A.V.C. voltage from the diode through the bottom side of the coil up to the control grid of the antenna amplifier tube. That connection usually goes to ground.

The Court: If the witness be handed a piece of chalk, can he mark the principal parts added?

Mr. Adams: Yes.

The Court: This may not be in the record.

Mr. Adams: The exhibit itself will be preserved and I imagine the chalk marks will stay on it.

By Mr. Adams:

Q88 How many different parts have you marked with the chalk?

A About nine.

Q89 And those are all the parts that were added?

A Substantially.

Q90 How many of those parts were condensers?

A Five.

Q91 And the other four were what?

A Resistors.

Mr. Adams: I would like to offer in evidence, your Honor, the pages of the Levy notebook that have been referred to by the witness, Mr. Philbin can examine the entire book, and I assume he will have no objection to my offering just those pages. Because this is Mr. Levy's company notebook that he uses in his work, I prefer to substitute copies if Mr. Philbin has no objection.

Mr. Philbin: No objection.

Mr. Adams: I offer pages 58, 59 and 60 of the Levy notebook in evidence as Plaintiffs' Exhibit 16.

(Received in evidence and marked "Plaintiffs' Exhibit No. 16.")

Mr. Adams: The Wheeler notebook that has been referred to, your Honor, will be identified by Mr. Wheeler later, and I should like to have the page referred to by the witness, page 75, marked for identification at this time.

Mr. Philbin: No objection.

The Court: It will be so marked.

(The same was marked "Plaintiffs' Exhibit A for identification.")

By Mr. Adams:

Q92 Referring to this page 75 in the Wheeler notebook No. 8 to which you referred will you tell me the circumstances under which you placed your initials on that page?

A After the demonstration of that radio set, and after we had inscribed our initials on that back panel, Mr. Wheeler asked me into his office and asked me to put my initials on this circuit, which is the one in the radio receiver to which we listened, and I inscribed my initials as they are there.

Q93 I notice there are initials "M.L.L." and the date August 11, 1926. Did you write the date there?

A Yes, sir.

Q94 Did you write the date there on August 11, 1926?

A Yes, sir.

Q95 That is in your handwriting?

A Yes, sir.

Q96 You referred to a visual tuning indicator as shown in your notebook on page 59. Is there any visual tuning indicator in this Stromberg-Carlson set, Plaintiffs' Exhibit 14, as it is now before you?

A The visual tuning meter is in the front escutcheon. I cannot tell whether that is the visual tuning meter or the standard volt-meter that was on there, but we used a similar volt-meter for the visual tuning meter.

Q97 Do you mean that the 601-B model had a standard volt meter as part of the set?

A Yes.

Q98 What was it used for?

A To indicate the filament voltages on the tube.

Q99 When you installed the Wheeler system of automatic volume control did you add another meter?

A Yes, we added another meter in the plate circuit of the antenna amplifier tube.



Q100 Could you tell now by tracing the connections whether the one which is on the front panel of the set was the standard volt meter or whether it was the visual tuning indicator?

A Both meters would be the same type. I could tell by checking through the connections to find where it has gone to.

Q101 Would it take you long to do that?

A The meter on this radio set, as hooked up, is the filament voltage indicator. Here are the leads where you attach the tuning indicator externally.

Mr. Adams: That is all.

*Cross-Examination*

By Mr. Philbin:

XQ102 Referring to your notebook, I find in some cases blank pages. What was your practice with respect to filling out and dating the pages in your notebook?

A My practice in filling out notebooks is to always use the righthand sheet and never put anything on the lefthand sheet unless it is something that is added later.

XQ103 On page 59 to which you referred, and which has the heading "Wheeler's Audiostat," there is a circuit diagram to which you referred and on the following page I find the words "Changing tap to 20. Helps range and decreases amp. to a level about 12. Tap at 30 amp. becomes less (and condenser is about 200)." Do those words have anything to do with the diagram on the preceding page?

A No, sir.

XQ104 To what did they refer?

A They referred to the work done on the page on the right. That would be page 60.

XQ105 As I understand you, your custom was to make

the first description of something new on the page on the right and then if there was anything further noted in connection with that same matter, to make an entry on the page<sup>2</sup> on the left which faced the page on the right?

A That is right.

XQ106 Is there any entry opposite page 59 which is the diagram of the Wheeler circuit to which you referred?

A No.

XQ107 Is there any reference in this note book to this so-called Wheeler Audiostat except on page 59?

A There may be some further back but I am not sure now. No, I think not.

XQ108 As you recall it, what was the day that Mr. Wheeler first told you about this Audiostat?

A I do not remember the exact day.

XQ109 About when?

A It was somewhere between the 4th and the 11th of August, 1926.

XQ110 And was that at Rochester?

A Yes, that was at Rochester.

XQ111 What work, if any, did you do on this Audiostat in Rochester after Mr. Wheeler told you about it?

A I changed this receiver cover.

XQ112 Did you make any written memorandum or notes in writing with respect to any work of yours at Rochester on this Audiostat except what may be contained on page 59?

A That is the only record I have of what I put in that circuit and it appears on that page.

XQ113 How long did it take you to make these changes in the Stromberg-Carlson set, concerning which you have testified?

A Probably a day or a day and a half.

XQ114 Did you do any work on this Audiostat ar-

...rangement, or a similar kind of arrangement after August 1926?

A Not immediately after.

XQ115 About when?

A Probably about two years after.

XQ116 I find in this note book many references to Mr. Wheeler and to the Hazeltine Laboratory. Will you tell us whether you were or were not in close touch with the Hazeltine people during the year 1926?

A Yes, sir, I was in very close touch and I worked with Mr. Wheeler for the most of that summer of 1926.

XQ117 And were you also in close touch with the Hazeltine people in 1927 and following years?

A I think in 1927 we were not as close as we were in 1926.

XQ118 But during that year and 1928 and the following years, you did have frequent conversations and discussions with the engineers of the Hazeltine people, including Mr. Wheeler?

A. From time to time, but I think after that year there was some interval.

XQ119 In this 601-B Stromberg-Carlson set concerning which you have testified as embodying this Audiostat arrangement, how many tubes were employed?

A I think six.

XQ120 How many tubes do the circuit diagrams to which you have referred show?

A They only show three.

XQ121 That is in your note book only three tubes are shown?

A Yes.

XQ122 You also referred to a page 75 from Mr. Wheeler's note book which is entitled "Audiostat Demonstration"?

A Yes, sir.



XQ123 How many tubes are shown in that circuit diagram?

A Five.

XQ124 How many tubes are in the Stromberg-Carlson set concerning which you have testified?

A Six.

XQ125 In what respect did the Stromberg-Carlson set differ from the circuit diagram shown on page 75 of the Wheeler note book?

A Do you mean the original 601-B or the receiver after it was changed to the Wheeler circuit?

XQ126 The receiver after it was changed? I had the impression that page 75 showed the changed receiver. That was the impression I received from your testimony.

A The difference is that one of the tubes was not used in the revised receiver, and that is why there are only five tubes shown here. The original receiver had a detector and two audio amplifier tubes, and this circuit in this note book does not show the complete receiver.

It assumes that another R.F. amplifier is on. This is really schematic and not an exact duplicate of the model. It merely shows those points in the receiver that are involved in the diode detector of the automatic volume control circuit.

XQ127 How many tubes were in the Stromberg-Carlson receiver before it was changed, and what was the function of each tube?

A There were six tubes in the Stromberg-Carlson receiver. There were three in the R. F. amplifier, one detector and two audio amplifier tubes.

XQ128 Does the sketch show two radio frequency amplifier tubes, one detector tube and two audio frequency tubes?

A Yes, it does.

**XQ129** Do the audio frequency tubes have anything to do with what you have termed the Audiostat arrangement?

**A** No.

**XQ130** Why was the radio frequency tube left out?

**A** The radio frequency tube does not enter into the circuit of the diode detector and the automatic volume control.

**XQ131** Do the audio tubes enter into that circuit?

**A** No.

**XQ132** You said that this apparatus operated satisfactorily. Did you make any measurements at any time on this receiver to see what the effect was of the Audiostat or A.V.C. arrangement?

**A** We did not make any actual laboratory measurements. We did make the practical listening tests and see the practical effect of automatic volume control by its operation on the meter.

**XQ133** You looked at the meter, but you did not make any record of what the meter showed?

**A** I do not know of any records of what the meter showed except that the meter is put in the circuit for the purpose of showing the change in plate current with signal strength on the antenna.

**XQ134** What type of tubes were used?

**A** 201-A, and I think 171 tubes in the output.

**XQ135** You mean in the audio output?

**A** That is right.

**XQ136** Was the detector tube a triode connected as a diode?

**A** Do you mean in the original set, or in the revised set?

**XQ137** In the revised set as shown on page 75?

**A** Yes, sir.

**XQ138** Do you know how much A.V.C. voltage was produced by that tube?



A No.

XQ139 Was there any grid battery employed with this set as revised?

A I do not know what you mean by "grid battery".

XQ140 Was any negative grid bias put on the grids of any of the amplifier tubes when the A.V.C. was not operating?

A No, sir. Those ran at zero potential. The filament and the grids were at the same potential. I will revise that. The grids of the amplifier tubes were biased—

XQ141 That is, the first two radio frequency amplifying tubes had their grids biased when no A.V.C. was operating, by what means?

A The panel has a distribution board on which we fed our B and C voltages as they are marked.

XQ142 So that the grids of the amplifier tubes did receive a C voltage from some source?

A I do not remember whether we had that on there at the very end or not. No, the first tube did not have any bias on it and could not have.

XQ143 The first tube is the one that has the A.V.C. control on it?

A That is right.

XQ144 And by your statement that it did not have any bias on it you meant in the absence of signal?

A That is right.

XQ145 Why do you say it could not have any normal or starting bias on it?

A Because the controlled grid returns to the diode cathode or diode filament and the difference of potential between the ground or the diode of the other is zero, or just the voltage drop across the filament.

XQ146 You have used the term or perhaps I have used it "grid bias." Does that mean as you have understood it the difference in potential between the grid and the cathode?



A Yes, sir.

XQ147 And what is the reference point of the cathode, does it mean that the grid is negative to the most negative of the filament or cathode when you say two or three volts negative grid bias?

A We usually take the negative side of the filament as the reference point which is commonly known as ground.

Mr. Philbin: That is all.

*Re-Direct Examination*

By Mr. Adams:

RDQ148 When you say that the grid of the controlled amplifier tube could not have any bias on it, do you mean it could not be arranged to have any bias on it or do you mean that as it is built in the set it could not have any bias on it?

A As the circuit shows, it could not have any bias.

RDQ149 If you wanted a bias on it, could you have a bias on it?

A I think so.

RDQ150 Would the automatic volume control circuit still work?

A Yes.

RDQ151 Mr. Philbin asked you whether you were in close relations with the Hazeltine Corporation in 1926 and 1927. Did you at that time or thereabouts establish relations with the Radio Frequency Laboratories?

A I think the year after that we worked with the Radio Frequency Laboratories.

RDQ152 Did you work closely with the Radio Frequency Laboratories?

A Quite.

RDQ153 Did you work as closely or more closely or less closely than you did with the Hazeltine Corporation?

A We worked as closely with the Radio Frequency Laboratories subsequently as we did with the Hazeltine Corporation during the summer of 1926.

RDQ154 Will you tell me whether when you began relations with the Radio Frequency Laboratories you to some extent discontinued the closeness of your relations with the Hazeltine Corporation?

A Yes, we did.

RDQ155 During what period was it that you did your subsequent work on automatic volume control?

A Subsequent work was done, I think, somewhere around 1929 or 1930. Maybe it was 1928.

RDQ156 At that time had you established these relations with the Radio Frequency Laboratories?

A Yes.

Mr. Adams: That is all.

*ReCross Examination*

By Mr. Philbin:

RXQ156 There are one or two questions I would like to ask you about this original Stromberg-Carlson set. As I understood you, the original set had a C bias for the first radio-frequency amplifier tube and that was used, of course, without the A.V.C. Then, as I understood you, that was changed when you put the A.V.C. on and the grid bias was removed from the first tube. Who told you, if you remember, to take off the grid bias from the first tube when the A.V.C. was used?

A I do not think anybody told me. I think I followed the circuit.

RXQ157 And the circuit was given to you by Mr. Wheeler?

A Yes, sir.

RXQ158 And that is what you understood were his instructions from the circuit?

A Yes.

Mr. Philbin: That is all.

(Witness excused.)

WILLIAM F. COTTER, was called as a witness on behalf of the plaintiff, in rebuttal, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 What is your present occupation?

A I am an engineer in charge of the Radio Engineering Department at the Stromberg-Carlson Manufacturing Company.

Q2 How long have you occupied that position?

A Just approximately a year.

Q3 Where were you employed prior to that?

A With the United American Bosch Corporation and its predecessor the American Bosch Magneto Company.

Q4 In what capacity?

A The same capacity.

Q5 You mean as radio engineer?

A As radio engineer under the direction of the Chief Engineer.

Q6 When did you begin your experience with radio?

A I began my experience professionally when I went to sea for the Marconi Company in 1917.

Q7 Where were you educated?

A At Stevens Institute of Technology, Hoboken, New Jersey.

Q8 Did you graduate from there?

A Yes, sir.



Q9 When was that?

A 1918.

Q10 What was your subsequent experience in radio?

A On completion of my technical school work I entered the Navy and served for approximately nine months in the Radio Operating Division of the New York Naval Communication District. On leaving the Naval service I spent a year with Mr. Paul Ware who was a Consulting Engineer, engaged in Army contract work.

On leaving Mr. Ware, I entered the employ of the Western Electric Company, spending two and a half years in New York mainly on ship to shore telephone development. On leaving Western Electric Company in the middle of 1922, I went to the Federal Telephone & Telegraph Company in Buffalo, New York for a period of two and a half years. Following that in August, 1925, I went to the American Bosch Corporation, remaining there ten years and three months, severing my connection there to go with the Stromberg-Carlson.

Q11 I would like to know whether or not you did radio work with the Western Electric Company?

A. Yes, radio work mainly on ship to shore telephone development work.

Q12 In this varied experience, did you ever hear of the 2-electrode Fleming valve as a radio detector?

A I remember it from a very early date.

Q13 What was its status among radio engineers as a detector in 1925 or 1926?

A I have no recollection of it being used in 1925 or 1926. Its status as a detector up to that time, to the best of my recollection, it was not held in very high esteem because of its low sensitivity, inasmuch as up to 1925 we were not provided with radio frequency amplifiers of any considerable capacity.

Q14 When did you first hear of automatic volume control?

A My first recollection is a paper at an I.R.E. meeting I attended in New York which was in 1927, I believe, at which Mr. Wheeler gave a paper on automatic volume control and illustrated the action of such a receiver by means of lantern slides.

The Court: What was the date of the meeting?

The Witness: I do not recollect. It was some time in 1927.

Q15 Had you been prior to that time familiar with the phenomenon known as fading in radio receivers?

A Yes.

Q16 And had you been familiar with the phenomenon of blasting in radio receivers?

A Yes.

Q17 Prior to the time that you heard the Wheeler paper did you know of any system of control that would cure or tend to cure this phenomenon of fading?

A. Not the phenomenon of fading.

Q18 Or of blasting?

A Yes, I recollect an expedient employed in curing blasting. It was to run the final power amplifying stage at low capacity so that the blasting peaks would exceed the capacity of the amplifier and, therefore, be smothered in the reproduction. The amplifier would handle up to a certain amount of audio volume and beyond that amount it would level off and while the reproduction might be distorted, the reproduction would not result in blasting.

Q19 Is that what is called a limiting effect?

A Yes.

Q20 Or overloading effect?

A We referred to the device as a "limiter." It was used in some ship to shore radio experimental equipment by the Western Electric.



Q21 I show you a copy of the proceedings of the Institute of Radio Engineers for January, 1928, and call your attention to the article entitled "Automatic Volume Control" for radio receiving sets by Harold A. Wheeler on pages 30 to 34, inclusive. Is that the paper that you heard delivered that you have just referred to?

A Yes, this is the paper.

Q22 Did that paper disclose a system which would tend to eliminate the effects of fading and bleating to which you have referred?

A Yes, sir, to my mind it did.

Q23 Does this paper disclose an automatic volume control system using a diode rectifier for automatic volume control purposes?

A Yes, it does.

Q24 At the present time in the Stromberg-Carlson Company what form of detectors do you use in your receivers for automatic volume control?

A We use the diode form universally.

Q25 When you say "universally," what do you mean?

A In all receivers built by the company.

Q26 Do you have automatic volume control in all of your receivers?

A Yes.

Q27 And as I understand it, in all of these the automatic volume control detector is the diode?

A Yes.

Mr. Adams: I would like to have that paper marked for identification as Plaintiffs' Exhibit B.

Mr. Philbin: No objection.

(The same was marked "Plaintiffs' Exhibit B for identification.")

#### *Cross Examination*

By Mr. Philbin:

XQ28 In the A.V.C. sets put out by the Bosch Com-



pany, is a tuning meter or visual indicator employed with each model?

A Up to what time?

XQ29 Up to the present time.

A I am not familiar with the American Bosch products at the present time.

XQ30 While you were with it?

A While I was with them most of the larger sets employed the tuning meter. I cannot recollect offhand whether there were varieties not employing the tuning meter.

XQ31 Did you have anything to do with the design of the smaller Bosch sets while you were there?

A No, sir, I did not.

XQ32 Did you have anything to do with the design of the larger sets?

A Yes, sir. May I interject this, please: In the smaller sets I presume you mean in the smaller sets containing automatic volume control.

XQ33 Yes.

A Those sets were engineered in a period while I was in Europe for the company and I was not directly in touch with the development.

XQ34 How long were you with the Bosch Company?

A Ten years and three months.

XQ35 During what years did the Bosch Company put out A.V.C. sets?

A As I recollect, starting in 1930 and continuing so far as I know today, A.V.C. sets were made in one form or other.

XQ36 You said you attended a meeting of the Institute of Radio Engineers in 1927 and heard Mr. Wheeler describe an A.V.C. system. Did you consider at that time that you understood from that description how to build a satisfactory commercial set employing A.V.C.?

A. No, sir, I could not make any such contention.

XQ37 What did you get from that talk and that paper?

A I got from it that it was a very interesting device that had some possibilities. I remember the discussion after the meeting in which someone—and by discussion I mean the talk in the back of the hall after the meeting, in which someone remarked that it looked to him it was a pretty complicated device to get together. Those are my impressions of the meeting.

XQ38 Have you any suggestion to make as to why the Bosch Company did not put out an A.V.C. set until 1930 after this paper had come out in 1927?

A Yes, sir. The Bosch Company was not a licensee of Hazeltine and therefore did not have this information other than that which appeared at the I.R.E. meeting.

XQ39 And that information in your opinion was not sufficient to construct a satisfactory broadcast receiver?

A Not offhand I should say entirely.

XQ40 You said something about Fleming valves or diodes and amplifiers. What relation, if any, has amplification got with a diode or a detector?

A In the sense to which I referred to it, it meant this, that without amplification before the diode, because of the low sensitivity compared to other types of detectors available even the crystal types, the diode was not generally considered a commercial device. It was not until the advent of radio-frequency amplifiers which would supply sufficient energy to the relatively insensitive diode that we were enabled to put it into commercial practice.

XQ41 Does a triode detector give some amplification as well as detecting?

A Yes, sir.

XQ42 Is it roughly equivalent to about another stage of amplification?

A It is roughly equivalent to that, yes, sir.

Mr. Philbin: That is all.

(Witness excused.)

The Court: The Court will recess for five minutes.

Mr. Davis: I understand, if your Honor please, that with the exception of this possible single witness, Mr. Philbin's case is completed, except that he is going to put in the depositions that were referred to in the opening statements, and the file wrapper of the Wheeler patent. I am mentioning that now because I would like to know if I can now, whether your Honor prefers to have those depositions read, or in what manner we shall treat them.

The Court: Reading from start to finish is rather a dull performance, and if you will just bring out the high lights, I shall be quite content.

Mr. Davis: Your Honor, we can leave that while Mr. Adams is going on with his fact witness.

The Court: Very good.

Mr. Adams: Now, Mr. Johnston.

FREDERICK ERNEST JOHNSTON, was called as a witness in rebuttal, on behalf of the plaintiffs, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 What is your occupation at the present time, Mr. Johnston?



A Chief Engineer of the Crosley Radio Corporation, Cincinnati.

Q2 Does that company manufacture and sell radio receiving apparatus?

A Yes, sir, it does.

Q3 For broadcast reception?

A Yes, sir.

Q4 Does it sell a substantial quantity of that apparatus?

A Yes, it does.

Q5 Approximately what volume of business does it do a year?

A In units of receivers or dollars?

Q6 Units of receivers will be all right.

A Approximately 500,000 units.

Q7 That is 500,000 receiving sets?

A That is right.

Q8 Will you briefly tell us what your experience has been in radio?

A I first became interested in radio in 1909 as an amateur, and continued that until 1913. In 1913, I worked for approximately a year as radio operator on steamships on the West Coast.

In 1917, I joined the Signal Corps of the United States Army, serving in the Radio Intelligence Division of the Army in France.

In 1920, I joined the Receiving Engineering Staff at the Lakewood Station of the Radio Corporation of America, and continued with receiving station engineering at Lakewood, New Jersey, Chatham, Massachusetts, Riverhead, Long Island, and two years in Poland on the construction of a high power receiving station, for the Polish Government, on behalf of the Radio Corporation.

I returned to Riverhead in 1924, as Engineer in charge of the high power receiving station of the Radio Corporation of America at this point.

In 1926, I entered the employ of the Hazeltine Corporation, and was with them, I believe, a year and a half.

In 1928 I became Chief Engineer of the Amrad Corporation, a subsidiary of the Crosley Corporation, near Boston.

In 1930, I was transferred to Cincinnati.

In 1931, I became Chief Engineer of the Crosley Corporation, and still occupy that position.

Q9 Did you ever have any experience with the diode detector during this period, say prior to 1925?

A As a ship operator on the Pacific Coast, in the receiving equipment, I used a Fleming valve detector. That is the only experience that I had with that type of detector.

Q10 During this period of time, did you have under your direction, radio engineers; were you associated with other radio engineers?

A During which time?

Q11 During the period of time prior to 1925?

A Yes, beginning with my association with the Radio Corporation, I had some two to ten engineers under my direction.

Q12 What was the status of the diode detector, among radio engineers in 1925?

A It was, to the best of my knowledge, not considered as a detector at all. That is, it was known as a device used as a detector in the earlier history of the art, but at that time, its use had disappeared as a detecting means:

Q13 In 1925, had you ever heard of automatic volume control?

A I had not.

Q14 When did you first hear of automatic volume control?

A In July, I believe, of 1926, when I joined the Hazeltine Corporation.

Q15 Did you ever attend any meeting of the so-called I.R.M. Engineers?

A I did.

Q16 Was this automatic volume control ever discussed at any of those meetings?

A It was discussed at the meeting in August of the I.R.M., as I recall it.

The Court: August of what year?

The Witness: August of 1926, sir.

Q17 Did you attend the delivery of the Wheeler paper on automatic volume control, at the Institute of Radio Engineers?

A I did.

Q18 I show you a copy of the paper entitled "Automatic Volume Control for Radio Receiving Sets, by Harold A. Wheeler", which has been marked in this case Plaintiffs' Exhibit B for Identification. Is that the paper that you heard at that time?

A It is.

Q19 Can you tell me whether that discloses the system of automatic volume control which was discussed at the meeting of the I.R.M. Engineers in August of 1926?

A Yes, it does.

Q20 Did that form of automatic volume control use a diode detector?

A It did.

Q21 Subsequent to that time, what has your experience been in designing or building radio receiving apparatus?

A During the two years that I have been with the Amrad Corporation in Boston, the design of three re-



ceiving sets came directly under my supervision, and since joining the Crosley Radio Corporation, the design of all of the receiving sets that have been manufactured by that organization, has been under my direction.

Q22 Have you had engineers working for you in the design of those receiving sets?

A Yes.

Q23 Have you gone over with them the problems that were encountered in the design of those receiving sets?

A Yes.

Q24 At the present time, does the Crosley Company use automatic volume control in its receiving sets?

A In most of the models, yes.

Q25 What type of automatic volume control is used?

A The diode type of automatic volume control as defined here.

Q26 Did your company ever have any experience with the so-called triode form of automatic volume control?

A Yes, a few models were made employing triode automatic volume control.

Q27 Do you use any form now other than the diode form of automatic volume control?

A We do not.

Q28 Why do you use that form exclusively?

A The simplicity of the diode form has, in practical usage, proven superior to the triode form both from the point of view of manufacturing cost and from the uniformity of product.

Q29 When you say "uniformity of product," are you comparing the diode form with the triode form of A.V.C.?

A Yes.

The Court: And the product being the quality of sound produced?

The Witness: No, the uniformity between one receiver and another one in quantity production.

Q30 When you say "uniformity," what operational aspect of the receiver does it refer to, the looks of it?

A No. The triode type of volume control gave us more production difficulties due largely to variation in the vacuum tubes themselves, due to structural difficulties in the vacuum tubes and to the electrical performance varying, due to that structural difference.

Q31 Would that give any trouble in use or in the "field" so-called.

A It would where it became necessary in the field to replace a tube that had failed with a tube that might be purchased at random. That tube might not function in that circuit in the same way that a selected tube had functioned in the factory.

Q32 Do you know of any standard reference book that is used in the radio industry giving the various circuits and constants of circuits as manufactured by the various manufacturers throughout the United States?

A Do you mean a reference manual to be used by service men?

Q33 Yes, on radio receiving sets.

A Yes, one such book is known, I believe, as Rider's Manual.

Q34 Is that known as the "Trouble Shooter's Manual"?

A It is used as a reference book by radio service men who operate from dealers and radio distributors.

Q35 You stated I think, that when the triode form of automatic volume control is used you had difficulty due to the variations among the vacuum tubes that were used for the automatic volume control and that this might give difficulty in the field?

A I might qualify that by stating that that was the

reports that came to me from men who are under my direction, as their objection to the continued use of that type of circuit.

Q36 Was there any such difficulty with the diode form of automatic volume control?

A I do not recall any.

Q37 Did the diode form of automatic volume control have any portion of its circuit which corresponded to that portion of the triode automatic volume control that gave the difficulty; in other words, what was there about the triode form of automatic volume control that gave the difficulty, whereas the diode form of automatic volume control did not?

A In the triode form the variation between tubes in the amount of plate current present with a given grid voltage was a variable factor and to get the best A.V.C. performance it required a very uniform plate current for a given grid voltage between one tube and another tube. As I recall, that was our biggest difficulty, variation from one tube to another, and not with any one tube.

Q38 You say that was due to variations in the plate circuit, is that right?

A Variations in the plate current of the tube.

Q39 Was there any corresponding plate current in the diode form of automatic volume control?

A No. The current flowing in the diode circuit is dependent upon the signal voltage, whereas the plate current flowing in the triode is dependent upon a plate battery being supplied and internal constants of the tube.

Mr. Adams: That is all.

*Cross Examination*

By Mr. Philbin:

XQ46 Is the Crosley Company a licensee at the



present time of the Hazeltine Corporation?

A Yes, sir.

XQ41 And has it been a licensee since about 1926?

A 1926 or 1927, and I am not quite sure.

XQ42 You said that the current in the diode was not dependent upon a plate battery, as I understood you?

A That is correct.

XQ43 And I suppose the reason for that is that the diode itself does not have a plate or B voltage?

A That is correct.

XQ44 Is not, however, the operation of the diode and the amount of work performed by it dependent upon the B voltage in the preceding tube?

A No, I do not analyze it that way. It is dependent upon the change in the plate current caused by the carrier signal in that circuit.

XQ45 I will refer for convenience to the Wheeler reissue patent, Figure 1, merely for illustrative purposes. In Figure 1 the first tube is a radio-frequency amplifier tube, the second tube is a radio-frequency amplifier tube, the third tube is a radio-frequency amplifier tube, the next tube is the diode or a triode connected as a diode, which performs the function of obtaining the A.V.C. voltage and also of separating out the audio-frequency currents. In the diode there is no B voltage. However, the preceding tube 28, and indeed each of the preceding tubes, do they not have a B supply?

A Yes, they do.

XQ46 Is not the energy that comes into the diode and which makes it operate dependent upon the plate supply in those preceding tubes?

A The voltage developed across the secondary of the transformer which feeds the diode is dependent upon the degree of amplification which is provided by the three preceding tubes as you have described them.

Those tubes, in order to amplify, must be provided with a plate voltage. In that respect the alternating voltage which is available across the diode is dependent upon the plate voltage of those previous tubes.

XQ47 Those preceding tubes are triodes, are they not?

A Yes.

XQ48 Does not then, in this system of Wheeler, Figure 1, the A.V.C. current or energy depend upon a B supply?

A I would not analyze the circuit in that manner, no. The function of amplification depends on a plate voltage and those preceding tubes, 1, 2 and 3, supply an amplification. In my analysis those tubes might be replaced with some form of generator which was supplying an alternating current to the transformer secondary, which is feeding the diode, and the fact that there is a plate voltage present for those preceding tubes is only incidental to the function of the A.V.C. circuit.

XQ49 The A.V.C. circuit will not operate without it, will it?


A The A.V.C. circuit will not operate without an alternating signal voltage applied to it.

XQ50 And that alternating signal supply voltage is dependent for its existence, is it not, upon the B supply in the preceding tubes?

A It is dependent on the fact that there is an amplifier circuit in there, which has a B supply, yes, sir.

XQ51 And the amount of energy which the A.V.C. tube gets is dependent, is it not, upon the amount of B supply, that is, the more B supply, the more energy, and vice versa, within, of course, reasonable limits?

A Within the limits of the operation of the tube, such group of tubes as an amplifying system.



**XQ52** In a triode rectifier, is there both amplification and rectification?

**Mr. Philbin:** I should say here that I have been using the terms "rectification" and "detection" interchangeably. I believe there is some technical difference between them, but the patent treats them both as the same, and I think throughout this case, we have used them as meaning the same thing.

**XQ53** Now, in a triode rectifier, is there both amplification and detection?

**A** In general, yes.

**XQ54** Is the amplification due to the B supply in a triode detector?

**A** That is correct.

**XQ55** Well, is it not in effect what Wheeler has done is to take out the amplifying part of a triode detector and put it in a separate tube ahead of the detector?

**A** May I have that? (Question repeated.)

**XQ56** I should add, Mr. Johnston, I am talking only with respect to this matter of B supply, and to the question of whether or not this diode of Wheeler's is not dependant upon a B supply which is in the preceding tube, instead of being in the same tube as in a triode?

**A** I do not believe the question of amplification is tied up—is connected with the diode function in this case. That is, it is quite possible that the loss in amplification in any particular combination of tubes might be regained in the design by increasing the amplification both ahead and after the diode; that is, either as the third tube in this particular diagram, or in the fifth tube, which is an audio amplifier. That loss in efficiency of the diode as compared with the triode detector, can be by design, made in either place.



XQ57 But looking at this figure, and looking at the output of the detector, is it not true that the energy which comes out of the output, is dependent upon first, the signal currents, which come in, and second, upon the B supply, which aids in amplifying those signals?

A May I have that read? (Question repeated.)

The Witness: Yes.

XQ58 And if the B supply was weakened, the output would be less?

A That is true.

XQ59 Now, will you explain to me then what you testified to on direct examination, as there being a difference between using a triode and a diode in that in one case the operation was independent of the B supply, and in the other case it was not independent of the B supply?

A In the triode type of detector, as we have employed it, the detector tube itself, and an additional amplifier tube was employed to amplify the amount of the voltage being fed back to control the grids of the control tube. As I recall, our difficulties arose from the characteristic of a tube which is in addition to any tube shown in this circuit that we have been discussing.

XQ60 What did that tube you spoke of, consist of, a triode or a diode?

A A triode.

XQ61 And it acted to rectify?

A No, it acted to amplify the voltage which was being fed back to the grids of the control tube.

XQ62 And then after this amplifier tube operated, then, was there a detector which produced the A.V.C. voltage that operated the grid?

A No. The tube I have reference to acted as a direct current amplifier.

XQ63 What was the connection, if any, of the Amrad

Company to the Crosley Company at the time that you went with the Amrad Company?

A The majority interest in the stock holdings were owned by Mr. Crosley.

XQ64 What time did you go with Crosley, what date?

A March, 1930.

XQ65 Were you with Amrad from 1926 to 1930?

A No, from 1928 to 1930.

XQ66 Did Amrad manufacture broadcast receivers?

A Yes.

XQ67 Did any of these receivers employ automatic volume control?

A They did not.

XQ68 When you went to Crosley, in 1928, was that company manufacturing any sets of automatic volume control?

A You mean in 1930?

XQ69 In 1930, yes.

A They began that year to manufacture sets using automatic volume control.

XQ70 Did those sets have a tuning meter?

A No.

XQ71 What kind of an A. V. C. detector was employed, that is, a diode or a triode in 1930?

A A triode in 1930.

XQ72 When did Crosley first commence to use a diode, in what year?

A In 1931.

XQ73 Was the tube or tubes in the 1931 Crosley sets which were controlled by A.V.C. action, of the so-called variable Mu type, and also having the screen grid feature?

A I believe the tubes in the sets made in 1930, were not of the variable Mu type.

XQ74 In 1931?

A In 1931, I believe they were.

XQ75 You said that a large number of the present-day Crosley sets employed automatic volume control. Can you give us a general idea of about how many sets, or what proportion of sets turned out by Crosley, employ A.V.C., that is, approximately, annually?

A It is approximately 60 per cent. of the total number of sets.

XQ76 And about how many approximately of that 60 per cent have a tuning meter or other visual indicator?

A About 30 per cent.

XQ77 About 30 per cent of the 60 per cent?

A Yes.

Mr. Philbin: That is all.

*ReDirect Examination*

By Mr. Adams:

RDQ78 Can you give us any approximate idea of the quantity of sets that you have made using diode automatic volume control?

A About 650,000.

RDQ79 And about how many using non-diode automatic volume control?

A Around 40,000.

RDQ80 You were asked by Mr. Philbin whether the Crosley Company was the licensee of the Hazeltine Corporation. Is the Crosley Company also a licensee of the Radio Corporation of America?

A Yes, it is.

RDQ81 And has it been for a number of years?

A It has.

RDQ82 Has it been since 1930?

A Yes.

RDQ83 You were asked "whether the radio-frequency



amplifier preceding the detector in the radio receiver shown in the Wheeler patent, Figure 1, was dependent upon the B supply and I would like to ask you whether the operation of the whole set is not dependent upon the presence of the B supply?

A It is most emphatically.

RDQ84 Is not that true of every set that uses 3-electrode vacuum tubes?

A It is.

RDQ85 Is it not true of every modern radio set?

A Yes, it is.

RDQ86 Is the detector in a set using a triode for a detector dependent upon the B supply? Does it have a B supply in its circuit?

A Yes, it does.

RDQ87 When you use a diode detector in a radio set, does that diode detector have a B supply in its circuit?

A No.

RDQ88 You were referred to the plate supply of the amplifier tube which preceded the detector. Is that plate supply critical—Mr. Philbin suggests that I call it a B supply—is that B supply critical as to voltage?

A May I have the question again?

(Last question repeated as recorded.)

A No, not in the commonly accepted term.

RDQ89 Is the B supply of the triode which is used for triode automatic volume control critical as to voltage?

A The B supply as such is not critical. The voltage developed across the resistance in the plate of such a tube may vary between one tube and another tube, and that is the point I wished to bring out in the comparison of the quantity production item, that variations in the tubes themselves in quantity production

was the difficulty, and not a difficulty in any one particular set.

RDQ90 How does that manifest itself in the circuit, as a variation in the voltage or the current or what?

A As a variation in the amount of automatic volume control that is supplied back to the controlled tubes.

RDQ91 What does that depend upon with the triode form of automatic volume control?

A If the voltage supplied back to the controlled tubes is insufficient, serious overloading will occur in the amplifier, that is on loud signals, and cause serious objectionable distortion on the part of the customer. If the voltage supplied is too great, then the sensitivity of the receiver is materially reduced, again causing complaint.

RDQ92 In the triode form of automatic volume control, is the triode used as an amplifier?

A In the system that we used, it was.

RDQ93 And does the amount of voltage fed back for automatic volume control purposes depend upon how much that tube amplifies?

A Yes.

RDQ94 And is that the effect that you are talking about when you say that it varied from tube to tube?

A That is right.

RDQ95 And did that depend upon the fact that it had a plate circuit with a B supply in it?

A Yes.

RDQ96 And is there any corresponding function in a diode detector or in the diode form of A.V.C.?

A No corresponding function, as I analyze the circuits, no.

Mr. Adams: That is all.

*Recross-Examination*

By Mr. Philbin:

RXQ97 I understood you to say in answer to Mr. Adams' recent questions that the tubes you used or tried to use in 1930, were not uniform, that is, the triodes were not uniform and, therefore, you used the diodes. Will you tell us, if you can, what was the mechanical or electrical trouble with these triodes that came to you which made them not uniform in their operation?

A. In one particular tube, I am using arbitrary values and not definite, a negative voltage of 10 volts on the grid of that tube might give a 10-volt drop across the fixed resistor in the plate of that tube.

RXQ98 May I interrupt—

Mr. Davis: Let him answer.

Mr. Philbin: He is not answering.

Mr. Davis: Yes, he is.

Mr. Philbin: I asked for the physical characteristics of the tube and not as to how they operated.

The Court: Perhaps the answer is irresponsible, but had it not better be concluded?

Mr. Philbin: All right, your Honor. I do not think it will be very helpful, but I will be glad to have Mr. Johnston state the result.

The Court: You were interrupted.

A (Continued) With a given grid voltage on the amplifier tube in question, as I said before, a direct current amplifier, with one tube, that might develop a voltage of 10 volts across the resistor in the plate circuit. Another tube under those identical voltage conditions might develop 15 volts across the resistor in the same situation. That was a condition structurally inherent in the tubes. Those



conditions still exist, but they are of relatively little importance except in this particular circuit where we did have that difficulty.

RXQ99 Can you tell us what were the structural differences or the reasons why one tube would operate differently from another generally?

A. I am not a vacuum tube engineer. I understand, however, that the mechanical spacing between the elements was the condition that caused this variation from one tube to another.

Mr. Philbin: That is all.  
(Witness excused.)

LESLIE F. CURTIS, was called as a witness on behalf of the plaintiffs, in rebuttal, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 What is your present occupation, Mr. Curtis?

A I am Chief Engineer of the Radio Division of the United American Bosch Corporation at Springfield, Massachusetts.

Q2 How long have you occupied that position?

A Since 1930, when the corporation was reorganized.

Q3 What position did you have prior to reorganization?

A I was Chief Engineer of the predecessor of that company, the American Bosch Magneto Corporation.

Q4 What was your first contact with radio?

A About 1917 or 1918, I gave courses to under-graduate and graduate students at the University of Washington.

Q5 Were these courses in radio?

A In radio, yes, sir.

Q6 What was your education?

A I graduated in 1910 from Tufts College with the degree of Bachelor of Science in Electrical Engineering and from the University of Washington in 1916, with the degree of Master of Science in Electrical Engineering.

Q7 What was your first employment?

A I was first employed at the General Electric Company at Schenectady, New York, from 1910 to 1912.

Q8 And after that?

A. From 1912 to 1920, I instructed in the Electrical Engineering Department at the University of Washington, first as instructor and later as Assistant Professor.

Q9 What was your first practical experience with radio?

A When the first receiving set of the then American Bosch Magneto Corporation was designed in 1925, under my direction.

Q10 Prior to that time had you been familiar with the literature relating to radio?

A I had.

Q11 Did you have any activity in radio associations or societies?

A I was an associate member of the Institute of Radio Engineers and just before leaving Seattle in 1920, I was Chairman of the Seattle Section.

Q12 Prior to 1926, had you ever heard of automatic volume control?

A No, sir.

Q13 From what source did you derive your first knowledge of automatic volume control?

A The first workable system was that described by Mr. Wheeler in his New York paper.

Q14 What time was that?

A I believe that was presented in 1927.

Q15 Did you attend the meeting?

A I did not.

Q16 How did you hear of it?

A My associate Mr. William F. Cotter attended the meeting and gave me an account of the paper.

Q17 Prior to that time were you familiar with the phenomenon of fading?

A Yes, sir.

Q18 Were you also familiar with the phenomenon known as "blasting" in a radio receiving set?

A Yes, sir.

Q19 Did this automatic volume control which you say was disclosed by Wheeler have any effect on fading or blasting?

A It seemed to offer a practical solution of the problem.

Q20 I show you a copy of the paper "Automatic Volume Control for Radio Receiving Sets, by Harold A. Wheeler," which has been marked here Exhibit B for Identification, and ask you whether that is the paper to which you refer?

A It is.

Q21 Prior to 1926, had you ever heard of a diode detector?

A Yes, sir.

Q22 What was its status in 1925 and 1926 as a radio detector?

A It was generally considered to be insufficiently sensitive for use in receivers manufactured at that time.

Q23 Is it the sort of thing you would expect an engineer to put into a radio receiver?

A It was not at that time.

Q24 In this paper of Wheeler's, he shows, does he not, a diode detector?



A Yes, sir.

Q25 Well, did his suggestion that a diode detector be used, change your view in this matter?

A Not immediately.

Q25a Did you after hearing the Wheeler paper, attempt to build—or after learning of the Wheeler paper, attempt to build automatic volume control receivers?

A I did.

Q26 What form of detectors did you use?

A I employed so-called grid-leak triode, also a so-called bias detector, also a triode. I tried the so-called inverted vacuum tube by Professor Truman, and several others, which I do not recall at the present time. In my early experiments, I did not try the diode.

Q27 Have you actually produced commercial radio receiving sets using a triode form of automatic volume control?

A No, sir. May I ask for an interpretation of "triode"? Do you mean the detector which was used for audio signal, or the automatic volume control tube itself?

Q28 I mean the tube which is used for automatic volume control rectification?

A No, sir.

Q29 Has your company always used a diode as a rectifier for automatic volume control purposes?

A No, sir. Might I explain?

The Court: Certainly.

The Witness: The type of relay tube which we used for automatic volume control, was a screen grid tube, and was a tetrode, rather than a triode.

Q30 That had a triode with an additional element called a screen grid?

A Yes, sir.

Q31 And that was used for automatic volume control purposes?

A Yes, sir.

Q32 Did you work out your first commercial design yourself, in your own company?

A We had considerable assistance in the constants of the circuits used by information supplied us from the Radio Frequency Laboratories at Bloomfield, New Jersey.

Q33 What was the Radio Frequency Laboratories?

A It was a consulting organization under which my firm was licensed.

Q34 Did they design sets for you?

A They supplied us circuit information. We applied the suggested information to practical designs. They also tested our designs in their own laboratories.

Q35 When did you build your first automatic volume control set?

A In 1930.

Q36 Did that use this so-called tetrode detector, for automatic volume control purposes?

A Yes, sir.

Q37 Was that design recommended by the Radio Frequency Laboratories?

A It was.

Q38 Did you ever build commercially the receiver using the diode form of automatic volume control?

A Yes, sir.

Q39 When was that?

A The first use of a diode for that purpose was late in 1931, in our organization.

Q40 Was that design recommended by the Radio Frequency Laboratories?

A It was.

Q41 At the present time, do you build sets using automatic volume control?

-A Yes, sir.

Q42 What form of automatic volume control do you use?

A We are at present using the diode form.

Q43 Do you use that exclusively, or do you use some other form as well?

A We are using that exclusively.

Q44 Why did you use the diode form of A. V. C. in preference to other forms?

A Because the diode itself provides demodulation of the signal or so-called detection, which is inherently linear, and not subject to overload, as in other types, and because the same rectifier may be used to supply the control voltage applied to the grids of the controlled tubes.

Q44 Does the triode form of automatic volume control, or the so-called tetrode form that you have referred to, have the same advantages?

A It does not.

Q45 Did you ever have any difficulties with your non-diode forms of automatic volume control that were inherent in the systems themselves?

A Yes, sir.

Q46 What were those difficulties?

A The greatest difficulty which was inherent in this type, was due to a variation in the control voltage available for the controlled grids, because of the variation in the operation of the relay tube.

Q47 Was that a 3-electrode tube?

A That was a 4-electrode tube in the early designs.

Q48 And that was the one we have called the "tetrode"?

A Yes, sir.

Q49 That was a screen grid tube?

A Yes, sir.

Q50 Do you regard Rider's Trouble Shooter's Manual, as a reliable source of information as to the cir-



uits and their constants of the various receivers made by the various manufacturers throughout the United States

A Yes, sir.

Q51 Do you rely on it yourself for such information?

A We frequently use it in the Engineering Department as a source of information.

Q52 Do you supply information to that publication for publication purposes?

A Information concerning our receivers is in the publication. I am not sure of the channel through which it reaches the publication.

Q53 Is your company the Bosch Company, a licensee of the Hazeltine Corporation?

A Yes, sir.

Q54 Is it also a licensee of the Radio Corporation of America?

A Yes, sir.

Mr. Adams: That is all.

#### *Cross Examination*

By Mr. Philbin:

XQ55 What was your first experience with a diode detector, that is, about when?

A Sometime in 1931, when a circuit suggested by the Radio Frequency Laboratories was investigated, and finally incorporated in a production model made by my company.

XQ56 I did not make myself clear. What was your very first experience with a 2-electrode or diode rectifier or detector? I understood that you had known about them, and perhaps you used them as early as 1925, or so?

A I had never used the device. I had read of it in the literature on the subject.

XQ57 You said, I believe, that the diode was insen-

sitive at some time prior to 1930. Do you remember what that period was when you said the diode was insensitive?

A Until about the end of 1930, we did not consider the diode sufficiently sensitive for use for this purpose.

XQ58 What do you mean by "sensitive"? Do you mean that you did not get enough out of the diode for what you put into it?

A I mean exactly that. That is the amount of audio frequency output voltage available with a given input voltage of radio frequency signal, modulated in the ordinary manner.

XQ59 Well, now, is the diode changed in any way so far as you know, since 1925, with respect to being more or less sensitive?

A No, sir.

XQ60 That is, the diode itself has remained the same, substantially?

A Yes, sir.

XQ61 But when you spoke of the diode being more sensitive, it might perhaps have been more accurate to say that the diode was receiving more input energy; is that right; that is, there was more amplification with the diode?

A I did not intend to give the impression that the diode had changed in sensitivity, but that our use of the diode was different. That is, we used it with circuits before and after it, which were used in a different manner, making it practical in its later application.

XQ62 That is, in the earlier days the diode was put in the circuit which did not have much amplification and then in the later days the diode was put in a circuit with more amplification, is that it?

A Yes, sir.

XQ63 Can you tell us approximately what percentage

of radio broadcast receivers put out by the Bosch Company now has A. V. C?

A I believe of the present models all except one in the alternating current line. There are a few special purpose receivers which do not have automatic volume control.

XQ64 Does that mean that 90 per cent or more of the sets sold have A. V. C?

A Yes, sir.

XQ65 And what percentage of those have a tuning meter or visual indicator, approximately?

A In percentages of models, it is about 50 per cent. It is considerably less than that in percentage of total receivers sold.

XQ66 Do the cheaper sets not employ a tuning meter or visual indicator?

A They do not.

Mr. Philbin: That is all.

*Re-Direct Examination*

By Mr. Adams:

BDQ67 What is the total annual production of the United American Bosch at the present time?

A I have no actual knowledge on the subject. My belief is that it is approximately 150,000 sets a year.

RDQ68 There was one of your answers that I must have missed or at least I did not hear Mr. Philbin's question, but I will ask you again, had you heard of automatic volume control prior to 1926?

A I had not heard of any workable system. I believe that the desirability of a system which would accomplish the result had been discussed among our engineers.

Mr. Adams: That is all.

(Witness excused.)



WILLIAM LEROY DUNN, was called as a witness in behalf of the plaintiffs, in rebuttal, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 What is your present occupation, Mr. Dunn?

A Chief Engineer of the Belmont Radio Corporation of Chicago, Illinois.

Q2 What is the annual production of that company?

A Do you mean the production—

Q3 Quantities of radio receivers?

A In the order of 300,000 sets per year.

Q4 What has your experience been with radio? Can you summarize that for us?

A Briefly, I was interested in it as a kid, as an amateur. After that my interest dropped in it. Upon completion of my University training, I became reinterested in it and entered the Freshman Company at that time in 1926, and I was with the Freshman Company from 1926 to 1928.

Q5 What position did you occupy with the Freshman Company?

A For the last year I was in charge of engineering.

Q6 And what was the business of that company?

A The manufacture of radio receivers.

Q7 Were you in charge of the manufacture of the radio receivers?

A I was not in charge of the manufacture of radio receivers. Mr. George Eltz was Vice-President in charge of engineering and production.

Q8 And what was your job?

A I reported to Mr. Eltz in charge of the Engineering Department.

Q9 And was it your duty to design the receivers?

A It was.

Q10 Proceed.

A Subsequent to that I was Chief Engineer of the Colonial Radio Corporation during the year 1929.

Q11 Were you there designing radio receivers?

A Designing radio receivers. In 1930 and 1931, Chief Engineer of the Sprague Specialties Corporation. That is not a radio set manufacturer. It is a manufacturer of parts for radio receivers, until about June of 1931.

From June, 1931, until January, 1932, I was connected with the Engineering Department of the Grigsby-Grunow Company or Majestic Company and I was there in the so-called capacity of emergency engineer. The first half of 1932, I was connected with the United Air Cleaner Corporation making Sentinel receivers in the capacity of Assistant Chief Engineer. From there I went back to the Grigsby-Grunow and was connected with the Grigsby-Grunow Company during the last half of 1932 as Assistant Chief Engineer.

Q12 Did they produce the so-called Majestic Radio receivers?

A They produced the Majestic receiver.

Q13 What was your position with the Grigsby-Grunow Company at that time?

A Assistant Chief Engineer.

Q14 What did you do after that?

A After that I went to the Detrola Radio Corporation in the capacity of Vice President in charge of engineering and production.

Q15 And then?

A About October of that year I went to the Belmont Radio Corporation, October, 1933, and have been with that company since that date in the capacity of Chief Engineer.

Q16 In 1926 did you know how to incorporate automatic volume control in a radio receiver?

A I did not.

Q17 Had you ever heard of the automatic volume control receiver?

A I had not. I had heard of suggestions of such things but I never heard of any system being actually presented. I had heard of limiting devices, for example.

Q18 Limiting devices?

A Yes.

Q19 What do you mean by a limiting device?

A A device which depends upon the overload of the devices to limit the signal and prevent blasting or overload of the receiver. For instance, we had it in all vacuum tube circuits of that sort, that is a signal which was too strong for the input tube or the detector tube to handle, would cause the detector tube to block, and by blocking I mean a charge would be built up on the grid sufficiently negative to cut the tube off, thereby cutting off its amplifying function and causing the set to be dead until such time as the charge had leaked off.

Q20 When you say "blocking", does that mean that the tube was operative or inoperative while it was blocked?

A It was inoperative while it was blocked.

Q21 You say that prior to 1926 you did not know how to incorporate automatic volume control in a radio receiver, and I ask you whether you had prior to that time read the paper by Greenleaf Whittier Pickard, which was published in the proceedings of the Institute of Radio Engineers in 1924, and entitled "Short Period Variations in Radio Reception"?

A I believe I had, yes.

Mr. Adams: That paper is one of the papers included with the defendant's prior art exhibits.



Q22 When did you first learn how to incorporate automatic volume control in a radio receiver?

A- It was either in November or December, 1927, one of my engineers in the Freshman Company attended a meeting of the Institute of Radio Engineers, at which meeting Mr. Harold Wheeler gave a paper. This engineer brought me a preprint of that paper which was distributed at the meeting.

Mr. Adams: I will offer in evidence at this time this paper that has been referred to. It has been referred to previously as Plaintiffs' Exhibit B for identification and I now offer it in evidence as Plaintiffs' Exhibit 17.

Mr. Philbin: May I ask the purpose of this paper? It certainly cannot be used to add to or supplement the disclosure in the patent itself, as your Honor pointed out, in the American Tri-Ergon case.

Mr. Adams: If I may just interrupt for a minute. I expect to call Mr. Wheeler and I had been marking it for identification up until this time with the expectation that Mr. Wheeler would identify it, but it seems to me that it is clearly identified by all the other witnesses and so pertinent to the case that I offer it in evidence at this time. It has a bearing on what Mr. Wheeler disclosed, and it also has a bearing on what these engineers learned, and the source from which they learned it, and otherwise I would have to ask the engineers in considerable detail as to exactly what was disclosed in that paper. It seems to me that it is quite illuminating on the subject to have it before the Court.

The Court: Any objection to its being admitted as atmosphere?

Mr. Philbin: No, your Honor.

(Received in evidence and marked "Plaintiffs' Exhibit No. 17.")

By Mr. Adams:

Q23 I show you a paper entitled "Automatic Volume Control for Radio Receiving Sets", which has been marked Plaintiffs' Exhibit 17 and ask you if that is the paper to which you referred?

A That is the paper.

Q24 Have you ever had any experience with the so-called triode form of automatic volume control?

A Yes. Do you mean in a receiver that I have designed or people responsible to me have designed?

Q25 Either one would be sufficient.

A Yes.

Q26 Have you had any experience of a similar nature with the diode form of automatic volume control?

A Yes.

Q27 Have you ever had any difficulties with the receivers using a triode form of automatic volume control?

A Yes, I have had difficulties.

Q28 What was the nature of those difficulties?

A The difficulties were more or less exactly of the same nature as Mr. Johnston pointed out, although the triode was used in a somewhat different fashion. At the United Air Cleaner Company, we used one type of receiver using the triode type of automatic volume control. This A. V. C. system was subject to considerable changes in initial bias due to the cut-off of the tube, these changes in initial bias appearing in the initial sensitivity of the receiver.

Q29 What practical difficulty did that give, if any?

A The practical difficulties were that receivers varied from receiver to receiver in the production line, and it

became necessary to carefully pick tubes having almost identical cut-off characteristics or plate current characteristics near cut-off. Also in the field we had some difficulty, I understand, although I was not there at the time it was reported, but we had some difficulty with the replacement of tubes.

Q30 Did the Grigsby-Grunow Company make a radio receiver with a triode form of automatic volume control?

A Yes, it did. That was previous to the time of my arrival with the company and that was their Model 160.

Q31 Did you know about the difficulties?

A Yes, they were in the difficulty—

The Court: Do you mean "Did you learn about the difficulties?"

Mr. Adams: I think the witness was just about to explain.

Q32 How did you know about the difficulties?

A At the time that I came to the Grigsby-Grunow Company the new engineering regime was in the process, that is, we were in the process of fixing up the troubles that we were having in the field with this receiver. It is my belief, although I cannot vouch for the exact accuracy of the figures, that at that time we pulled in from between 20,000 and 30,000 sets from the field that were in trouble from the use of this type of automatic volume control circuit.

Q33 What was the trouble?

A The trouble was with this particular type in which this was not the type of the United Air Cleaner, but it was still another type of triode circuit in which the tube was used as a D. C. amplifier, necessitating the design of the whole RF system some 135 volts above ground potential, and by ground potential I mean the potential of the chassis.



This meant that each coil and every other part that was mounted on the chassis had to be insulated from the chassis for that potential of 135 volts.

Further, an automatic volume control system very definitely necessitates the use of very high resistances in feeding the system, and the result was that with this potential and this whole system floating in the air, that very minute leakage of energy would cause the R.F. and I.F. amplifiers to be biased violently negative which would cause the set to be completely inoperative.

This leakage condition occurred in the field due primarily to humidity conditions, that is, moisture caused the various wires to be more conducting and caused the insulations to be more conducting. The leakage which occurred resulted in a very high negative bias on the R.F. amplifiers and resulted in the receiver being inoperative.

Q34 At the present time, does the Belmont Radio Corporation manufacture and sell radio receivers using automatic volume control?

A We do.

Q35 What type of automatic volume control do you use?

A At the present time we use the diode type of automatic volume control.

Q36 Why do you use that form of automatic volume control instead of some other?

A For several reasons. The first reason is that we found that that type was largely independent of the characteristics in the tubes, and the second reason is that we found it to be economical and the most economical system, and the third reason is that in over 430,000 sets manufactured with the diode type control, we have not had any trouble from the control.

Q37 Do you regard Rider's Trouble Shooters Manual, as a reliable reference book to show the circuits and

their constants of the various radio receivers made by the various manufacturers in the United States?

A I can not vouch for the other manufacturers. They reproduce our stuff correctly.

Q38 Do you have occasion to refer to it?

A Yes, I do, from time to time.

Q39 And do you, when you refer to it, rely on the information in it?

A Yes, and I have never found it to be unreliable, as yet.

Mr. Adams: That is all.

*Cross-Examination*

By Mr. Philbin:

XQ40 Will you tell us, Mr. Dunn, about what proportion of the sets sold by your company at the present time, have A. V. C.?

A Approximately 99 per cent. of them.

XQ41 And how many have a tuning meter or visual indicator?

A About 10 per cent. That is, out of 430,000 sets which have been made with A. V. C., 30,000 of the sets had a tuning meter or visual indicator.

XQ42 During that period were you with the Freshman Company?

A I was with the Freshman Company, I came with the Freshman Company in January, 1927, either January 1926, or January, 1927. It is quite a long time ago, and I do not remember the exact date. I was there during that year, and up until approximately November, 1928, at which time I went to the Colonial Radio Corporation.

XQ43 Is the Belmont Company at the present time, a licensee of the Hazeltine Corporation?

A It is.

XQ44 Did you have any practical experience in the

manufacture of broadcast receivers, before you went with the Freshman Company?

A. Well, during one summer, when I was in school, I designed a set for an outfit in Detroit, but only a few hundred sets were ever made.

XQ45 Did the Freshman Company sell radio broadcast receivers during the period that you were with it?

A. Yes.

XQ46 Is the Freshman Company still selling broadcasting receivers, so far as you know?

A. The Freshman Company is bankrupt.

XQ47 About when did it go out of business?

A. At the end of 1929, just after the crash. It went bankrupt under the name of the Earl Radio Corporation.

XQ48 Were you with it at that time?

A. I was not.

XQ49 Now, you spoke of some sets that were put out by the Grigsby-Grunow Company, and in which there were 135 volts above ground for the grids, and that these sets were unsatisfactory, I gather, because of the humidity conditions?

A. That is correct.

XQ50 Can you tell us a little bit more as to how the humidity conditions made those sets not very satisfactory?

A. Well, as I said, Mr. Philbin, it became necessary, that is, in the particular system that the A.V.C. was used, it became necessary to place the cathodes of the tubes, and the I F transformers, 135 volts above the chassis potential. That meant there was an extremely large voltage between all those parts and the chassis. Should any resistance develop, that is, should the insulation cease to be a perfect insulator, and cause a conducting path between those parts, and the chassis. It meant that the



chassis being 135 volts negative with respect to the grid, would place that 135 volts negative on the grids of the amplifiers, thereby biasing those amplifiers to be cut-off and causing the receiver to become inoperative.

XQ51 The humidity might cause a short circuit, so to speak?

A Yes, but the point is in that system, that a resistance of several megohms, 10 or 12 megohms, constituted a short circuit; whereas, in the system where the parts were brought nearer the ground, that would not be appreciable.

XQ52 Do any of the sets that you have put out have voltages in the same place of 135 volts or more above the chassis?

A No, sir.

XQ53 About what is the relation of the voltage of your sets?

A The highest voltage, which I think of, in any of our sets, the potential difference between the grid of the amplifier and the chassis, is in the order of approximately 6 volts for the no signal condition.

XQ54 Do you really think that this difference or the amount of difference in voltage, between the grids and the chassis above the ground is of practical importance?

A The difference in voltage is of practical importance?

XQ55 Yes.

A Yes, I think it is of great practical importance, the difference of 135 volts. However, I would like to qualify that, Mr. Philbin, by saying that the use of the triode type of A.V.C. did not necessarily require any such voltage difference between the parts of the set and ground.

XQ56 That is, this voltage matter is not directly related or connected to either a diode or a triode?

A Well, it is directly related to the triode. In this

particular case it was convenient to place those voltages that far above the ground with the use of the triode, while in the case of the use of a diode, there would be absolutely no necessity for the voltage difference.

XQ57 Is there any necessity with the triode of having such a difference of potential?

A There is the necessity of difference of potential somewhere. It does not matter whether you raise the chassis up, or lower the chassis to the parts, speaking in terms of potential gradient.

Mr. Philbin: That is all.

#### *Re-Direct Examination*

By Mr. Adams:

RDQ58 Mr. Philbin has brought out the Belmont Corporation is a licensee of the Hazelting Corporation. I might add it is also a licensee of the Radio Corporation of America, is not that true?

A That is true.

Mr. Adams: That is all.

(Witness excused.)

#### DISCUSSION

Mr. Davis: Is Mr. Waterman here?

The Court: You have seven and a half minutes.

Mr. Davis: Can we put in this at this time?

Mr. Philbin: I think so.

Mr. Davis: Here is Mr. Waterman now. Are you ready to answer that question? I would just as soon have it on Monday.

Mr. Adams: I have here, your Honor, copies of the pages of Mr. Levy's notebook which we offered with permission to substitute copies, and I

ask that the copies now be marked Plaintiffs' Exhibit 16. They are pages 58, 59 and 60.

Mr. Philbin: No objection.

The Court: Photostat admitted.

(Substitution was thereupon made.)

Mr. Adams: I will call Mr. Farrand.

CLAIR L. FARRAND, was called as a witness on behalf of the plaintiffs, in rebuttal, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 What is your present occupation, Mr. Farrand?

A I am president of the Independent Research Corporation.

Q2 What is the business of that company?

A Research and engineering, in the motion picture, acoustic and electrical field.

Q3 Have you had any experience in radio work?

A Yes, I have.

Q4 Will you review that for us briefly?

A My experience in radio began in 1910, when I was employed as a wireless operator by the United Wireless Telegraph Company. In 1911 I was employed by the Marconi Wireless Telegraph Company of America in the same capacity. In 1913 I was transferred to the Engineering Department of that same company, where I remained until 1919. During the World War I had charge of the design of wireless telegraph and telephone transmitting and receiving equipment for the Marconi Company. In 1920 I was associated with the Liberty Electric Company designing wireless telegraph and receiving equipment for ship-to-shore communication.



In 1922 to 1924, I was consulting engineer assisting in the design of radio broadcast receiving equipment for several companies, including the Atwater Kent Manufacturing Company, Pathe Phonograph and Radio Corporation, the R. E. Thompson Manufacturing Company. In 1924, I started my own company called the Farrand Manufacturing Company, which was engaged in the manufacture of radio broadcast receivers and loud-speakers.

This company was sold to the Brunswick-Balke-Collander Company in 1928; and I organized the United Research Corporation, of which I was President and General Manager. This latter corporation was later sold to Warner Brothers Pictures, Inc., acting as the engineering department of that company, until this year, when I organized the Independent Research Corporation, of which I am now the head.

Q5 Are you connected with Warner Brothers any longer?

A No.

Q6 In the course of this work that you have previously reviewed, did you have under your direction at any time, radio engineers?

A Yes, I did.

Q7 At what times?

A In the Marconi Company, I had a staff of engineers engaged in design of radio receiving and transmitting equipment, and also in the Liberty Electric Corporation. I contacted with the engineer staffs of the Atwater Kent Manufacturing Company, and the other radio companies I mentioned during that period; and in the Farrand Manufacturing Company, I had a number of engineers working on the design of radio and acoustic devices.

By the Court:

Q8 Did you ever participate in research?

A Yes, I directed it and observed the results; they reported to me.

Q9 Did you ever have any schooling in electrical work?

A My schooling was limited to high school, your Honor.

Q10 And your actual work in the laboratory?

A Yes and my experience in laboratories of electrical engineering and radio engineering, too.

By Mr. Adams:

Q11 In the Farrand Manufacturing Company, did you have any engineers?

A Yes, I had two or three engineers, designing radio equipment; and in the United Research Corporation, we had charge of the design of the radio receivers for the Brunswick-Balke-Collander Company.

Q12 In the course of this work to which you have referred, did you ever have occasion to use a diode detector?

A Yes, I have.

Q13 What did you use?

A My first use of the diode detector was in the Marconi Wireless Telegraph Company, in the reception of wireless telegraph signals. It was known as the Fleming valve, and was used in the company up until the advent of the audion as a regenerative receiver.

Q14 Was the audion a diode or a 3-electrode valve?

A The audion was a 3-electrode valve.

Q15 When the Fleming valve was used as a detector, was it used as a current producing device, or a potential producing device, or how was it used?

A It was used in a manner that would produce the maximum energy or response in the telephone receiver. This, of course, means that after the resistance of the telephones had been chosen for the maximum current, then the maximum current flows to the telephone.

Q16 Well, what I would like to find out was whether

you were interested in securing from the diode in that use, energy to operate a current operated device or of a potential to operate a potential operated device?

A You were interested in securing a current in the telephone.

Q17 Do you know anything about whether the amplification of energy prior to the detector was greater or less in the years succeeding 1915 than it was at that time?

A May I have that question. (Question repeated.) I do not think I understand that question.

Q18 Maybe I can put it this way: At the time that you used the Fleming valve, what was the energy that was applied to it as a detector?

A The energy applied to it came from the receiving antenna.

Q19 Was there any amplification preceding the detector?

A. No. There was no form of amplification. The loudness of the signal depended on the energy taken from the ether.

Q20 In 1925, for example, were amplifiers used in radio receiving sets?

A There were.

Q21 And could the Fleming valve detector have been used in those sets as a detector, just as well as it was previously used as a detector?

A It could have been used as a detector, certainly.

Q22 In other words, was there sufficient amplification at that time to enable its use as a signal detector?

A The Fleming valve when used as a detector in 1925, would have operated and given an audible signal. The signal would have been weaker than the existing detector gave.

Q23 When you say the "existing detector", what do you mean?



A At that time we customarily used a triode detector, which was more sensitive than the Fleming valve.

Q24 Do you know whether or not in 1925 the diode was used as a detector, as a matter of fact, in broadcast receivers?

A I did not know of any use of the diode in broadcast receivers at that time.

Q25 What was the last previous use of the Fleming valve as a detector that you know of?

A The Fleming valve generally ceased to be used after the years 1914 and 1915, when the regenerative audion receiver came into use.

Q26. In 1926 had you ever heard of a radio receiver employing automatic volume control?

A No, I had not.

Q27 What was the source of your first knowledge of automatic volume control?

A The source of my first knowledge of automatic volume control for a radio receiver was Mr. Wheeler's paper delivered before the Institute of Radio Engineers.

Q28 Do you remember when that was?

A I do not recall. My first knowledge was very near the time of its delivery, and I do not recall whether it was immediately before or immediately afterwards. It was within a month or so either way.

Q29. I show you a copy of the paper which is contained in the proceedings of the Institute of Radio Engineers for January, 1928, entitled "Automatic Volume Control for Radio Receiving Sets, by Harold A. Wheeler," and ask you whether or not that is the paper to which you have just referred; that is Exhibit 17 in evidence?

A Yes, it is.

Q30 Did you ever have any experience with the design or marketing of commercial receivers using automatic volume control?

A Yes, I did.

Q31 Can you tell us about that?

A In the United Research Corporation we designed a receiver utilizing automatic volume control for the Brunswick-Balke-Collander Company.

The Court: Did they furnish the design?

The Witness: No, we designed it.

Q32 Did some of your engineers work with you on that design?

A Yes, Mr. Carter was the head of the Radio group, and he reported to me on that work and he did the actual design work under my direction.

Q33 When was that, do you remember?

A The latter part of 1930.

Q34 How long had Mr. Carter been with your organization?

A He had been with the organization a year or two prior to that.

Q35 And where had he been before that?

A With the General Electric Company at Schenectady.

Q36 Did you use a triode automatic volume control system or a diode automatic volume control system in that set?

A We used a triode.

Q37 Did you have any difficulty with the set or was it quite satisfactory so far as the automatic volume control was concerned?

A It was not satisfactory. We had difficulties with it.

Q38 Do you recall what was the nature of the difficulties?

A The nature of the difficulty was inability to control different signal levels and distortion caused by the automatic volume control tube.

Q39 Did you take any steps to remedy the difficulty?

A We selected tubes for the sockets, which helped, but otherwise we were unable to remedy that design.

Q40 Did you finally get a successful design for your automatic volume control?

A The following year we did get a successful design of automatic volume control.

Q41 How did you get that design and what was it?

A We collaborated with the Hazeltine Laboratory on a receiver utilizing automatic volume control and the design involved a diode rectifier tube.

Q42 In 1929 and 1930, or whenever it was that you first designed that set for the Brunswick-Balke-Collender Company, were there any diode detectors available that you could have put into the set?

A There were no receiving diode or 2-electrode tubes available, as I recall, in the line of vacuum tubes used for radio receiving sets.

Q43 What would you do to get a diode at that time if you wanted one?

A You would use two of the electrodes in a 3-electrode tube. The general method that was adopted later was to connect the grid and plate together.

Q44 Did that present any obstacle in the adoption of the diode for detection or A.V.C. purposes?

A There would be an obstacle in adopting it. An engineer would hesitate to connect it together.

Q45 Why?

A You throw away the amplifying power of the grid and decrease what might be the efficiency of the set if the grid were connected in the circuit.

Q46 Let me see if I understand that. You mean that before the elements were connected together it had one amplification and after they were connected together it had another?

A What I mean to say is that if you had a 7-tube set you would expect to get a certain efficiency with those seven tubes and the grid being an inherent



part of one of them, would provide for an amplification of a certain amount, and if you connected that grid to the plate, you did not then get the amplification which you might have had had you utilized the grid.

Q47 If by connecting the grid and plate together you eliminated amplification, ordinarily secured in your 3-electrode detector, could you make up for that loss in any way?

A You could make up for it by adding another stage of amplification.

Q48 Did that present an obstacle to the adoption of the diode as an A.V.C. rectifier?

A I should think it would particularly when it was desired to produce a set with the minimum number of tubes for a given sensitivity and output.

Q49 After you got this set with the diode automatic volume control in it to which you have referred, did you do anything to determine whether it was satisfactory?

A Yes, we built about 12 models of this receiver and gave them very thorough field tests over a period of several months.

Q50 What did you find as a result of those tests?

A We were very well pleased with the performance of the automatic volume control.

Q51 Did it cure or eliminate the difficulties which you had previously had with the triode automatic volume control system?

A We concluded that it did.

Q52 Did you ever market these sets in commercial quantities?

A No, they were not.

Q53 Why was that?

A The Brunswick-Balke-Collender Company, and it was the Brunswick Radio Corporation at that time,

abandoned the radio business shortly after we completed these field tests.

Q54 Did that company have other lines of business?

A Yes, at that time it was owned by Warner Brothers Pictures who decided that they would not continue in the radio business, but carry on with their motion picture business instead.

Mr. Adams: That is all.

*Cross Examination*

By Mr. Philbin:

XQ55 With what were the early radio receivers used, earphones or loud-speakers?

A Earphones.

XQ56 And about when did the loud-speaker come into general use?

A May I ask if you are referring to wireless telephone receivers or broadcast?

XQ57 Either.

A The earphones continued to be used for a long time in wireless telephone reception and loud-speakers did not come into use until after broadcasting started in 1921, that is, generally.

XQ58 And about when did the loud speakers come into general use with radio broadcast receivers?

A That is what I meant to say in the previous answer, after 1921, when radio broadcasting came in, loud-speakers began to be used generally around 1923 or 1924.

XQ59 Which requires the most energy to operate, the ear phones or the loud speaker?

A The ear phone is operated at lesser energy, and the loud speaker is operated with greater energy, one producing more sound than the other.

XQ60 About how much more energy would be needed

to operate a loud speaker than ear phones, one or two stages of amplification?

A Generally two stages of amplification are used to provide for loud speaker operation.

XQ61 And how many for ear phones?

A Ear phones are operated on a detector, sometimes with one stage of audio.

XQ62 You spoke about some automatic volume control sets that you designed, or assisted in designing, for the Brunswick-Balke-Collender Company, or for the Brunswick Company. When was the first one of those sets designed?

A I believe in the fall of 1930. I recall it came on the market in 1931.

XQ63 And those sets contained triode A.V.C. detectors?

A Yes.

XQ64 And then the next type of set that you designed for this company, as I understand it, contained a diode rectifier, but did not actually come out on the market; is that correct?

A That is correct.

XQ65 When you designed this first set for the Brunswick Company that contained a triode, you had read, had you not, the Wheeler 1927 paper?

A Yes.

XQ66 And that paper described, did it not, the use of a diode detector?

A That is correct.

XQ67 Why did you not use the diode detector described in the 1927 paper, when you designed your 1930 set?

A The decision in that matter was largely made by Mr. Carter, who had active charge of the design work. The feeling we had at that time was the sensitivity of



the triode was so great that we wanted to use it. We did not know then that we would have difficulties in using it.

XQ68 You say the sensitivity of the triode; do you mean by that that in the triode there is amplification and in the diode there is none?

A I mean that the triode detector is a more efficient detector than the diode detector.

XQ69 Will not the triode detector amplify so that there is more output than there is input?

A If grid detection is used, there is a greater output.

XQ70 With the diode detector, is there any greater output?

A May I have that question?

The Court: A greater output?

XQ71 Than it has input?

A No. There is no amplification in the diode.

XQ72 So that it was considered desirable to use a triode with its amplification, rather than a diode without any amplification?

A Yes.

XQ73 The Wheeler paper showed, did it not, an ordinary triode tube, which was connected to operate as a diode?

A Yes.

XQ74 Were tubes of the so-called 201-A type available on the market in 1930?

A Yes.

XQ75 If such a tube had its plate and grid connected together, or if its plate was connected to the ground, would it not operate as a diode?

A If connected in a circuit it would operate as a diode, yes.

Mr. Philbin: That is all.

Mr. Adams: That is all.

(Witness excused.)

Mr. Adams: Now, Mr. Earnshaw.

DAVID P. EARNSHAW, was called as a witness in rebuttal, for the plaintiff, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 Mr. Earnshaw, what is your present occupation?

A I am employed as a Radio Engineer for the Philco Radio and Television Corporation.

Q2 How long have you been with the Philco organization?

A I have been with Philco since 1921 continuously. Previously, I was employed with them during 1918, and part of 1919. However, that early employment was with the, Philadelphia Storage Battery Company, also known as Philco.

Q3 During the time of your employment by the Philco organization, have you designed any of their radio receivers?

A I designed the R.F.—I designed, in fact, the complete receiver up to the second detector on all receivers developed by Philco, up until 1935. I had under my direction the design of them.

Q4 What experience had you had prior to the time that you designed radio receivers for Philco?

A I had a little professional experience in the meter field prior to my employment with Philco in 1918, and



I had had amateur radio experience since, dating back to 1915, and then—

Q5 When you speak of amateur experience, did you build any apparatus?

A Yes, I designed both my receiving and transmitting equipment from 1915 to date.

Q6 What other radio experience have you had?

A In 1921, when broadcasting started in, Philco had a demand for radio batteries. I, having had some previous radio experience, handled the design of those batteries being in the research department at that time.

We designed the various types of storage batteries which were commonly used in radio receivers at that time. Later on, seeing that eventually they would be replaced by something more satisfactory, we developed the socket power, which was a B power supply for radio receivers, supplying all the battery voltages. Then with the advent of the A.C. tubes, our market in socket powers was doomed to drop off, so that we went into the radio manufacturing business of developing receivers.

Q7 When was that?

A That was in 1927, about 1927.

Q8 When did you first hear of automatic volume control in radio receivers?

A The first I heard of automatic volume control, was the day after Mr. Wheeler's paper in New York. Mr. Holland, who was our Chief Engineer, attended the meeting of the I.R.E., where the paper was presented, and the following day brought the paper back to the laboratory and discussed it with the men.

Q9 I show you the Wheeler paper, Exhibit 17 in this case, and ask you whether that is the paper to which you refer (handing)?

A That is the paper.

Q10 Did you ever incorporate the automatic volume



control system of the Wheeler paper in a radio receiver?

A Yes.

Q11 And that was marketed by the Philco Company?

A Yes, we have made quite a few radio receivers, incorporating the diode A.V.C. shown by Mr. Wheeler in that paper.

Q12 Have you an approximate idea of how many you have made to date?

A A.V.C. receivers, we have made to date, in excess of four million.

Q13 What were the circumstances of your designing the first automatic volume control receiver; did you design that yourself?

A It was designed in conjunction with the Hazeltine Laboratory. We had a receiver on the market at the time which was not very satisfactory, and did not have the automatic volume control; and in discussing the faults of this receiver with Mr. MacDonald of the Hazeltine Corporation, we were trying to find a better type of receiver to put on the market. Mr. MacDonald suggested that we design a receiver having as one of the features automatic volume control.

In conjunction with the Hazeltine Laboratory, this receiver was designed and went into production.

Q14 I show you circuit diagram labelled "Philco Model 95". Can you tell me whether or not that is a circuit diagram of that apparatus that you have been referring to?

A That is the wiring diagram of the first A.V.C. receiver which Philco produced commercially.

Q15 Can you tell us which one of the vacuum tubes, as shown in that circuit diagram, was used for automatic volume control?

A This tube marked 227.

Q16 I notice there are three of them marked 227. Can you identify it some other way?

A It is the fourth tube from the left.

Mr. Adams: I offer that diagram in evidence as Plaintiffs' Exhibit No. 18.

Mr. Philbin: No objection.

(Received in evidence and marked "Plaintiffs' Exhibit No. 18.")

Q17 Was that receiver a success?

A That receiver met with considerable success on the commercial market, to such extent that it was continued the following year with only slight modifications.

Q18 Considering the conditions in those days, was that a high priced receiver or a low priced receiver?

A That was quite a high priced receiver. The tubes were quite expensive in that day, and the Model 95 receiver employed 9 tubes, which was more than any other receiver that we had on the market in our line.

Q19 How much did you say it sold for?

A It retailed, as I recall, probably in the bracket between \$150 and \$200.

Q20 And how much was an average priced receiver in those days?

A I would say that the average price receiver was between \$100 and \$150.

Q21 Did this Philco Model 95 receiver use variable Mu tubes?

A It did not

Q22 Did it use screen grid tubes?

A Yes, it used the screen grid tube.

Q23 How did its amplification compare with the amplification of other receivers that you were marketing?

A It was comparable. We had in production at the same time Model 87 receiver which was a neutrodyne



receiver employing triodes and the amplification was very close to being the same. There was no marked difference.

Q24 To what was the success of this model due?

A It was largely attributed to the satisfactory operation due to automatic volume control.

Q25 Was that apparent in the use of the set as compared with other sets?

A Oh, yes; in comparison with any other receiver not having automatic volume control of the Model 95, the automatic volume control would tend to counteract fading and maintain the volume at a constant level and also when tuning from one station to another, as you would tune past local stations you would not be troubled with the tremendous volume of the local stations and they would all closely maintain the same level.

Q26 Were there any other sets on the market at that time using automatic volume control?

A There had been an RCA model which employed automatic volume control and there had also been a model put out by the Howard Radio which had automatic volume control.

Q27 At the time that you were marketing your set was there any other set using automatic volume control?

A To the best of my knowledge there was not.

Q28 Thereafter did other companies manufacture sets using automatic volume control?

A The following year practically all large manufacturers had at least one set in their line having automatic volume controls.

Q29 Has the Philco Company ever used anything other than the diode form of automatic volume control in its receivers?

A There have been several receivers which have a



type of volume control which employs a triode, but its grid circuit still was used without any bias and the grid acts as a diode.

Q30 Is that a diode automatic volume control?

A That is a diode automatic volume control.

Q31 Have you ever used any of the so-called triode automatic volume control?

A No. From looking over the field of our competitors there seemed to be entirely too much trouble with the triode type of automatic volume control and from tests that we made in the laboratory it was not as satisfactory as the diode form of automatic volume control.

Q32 Did you ever incorporate diode automatic volume control in automobile sets?

A That was a very important factor in our success in the automobile field. The first automobile set which we produced had automatic volume control in it, and every automobile receiver that we have produced has had automatic volume control of the diode type.

Q33 About how many sets have you produced, automobile sets?

A It is rather hard to estimate, but I would say approximately half a million or in excess of that.

Q34 What were the circumstances of your going into the automobile set business?

A We acquired by purchase the Transitone Automobile Radio Corporation which was doing business on Long Island. We had in mind securing a radio market whose season did not coincide with the standard home radio market.

Q35 Had the Transitone Company been selling radio receivers for automobiles?

A Yes, they had.

Q36 Did those sets have automobile volume control in them?

A No.

Q37 Were they successful?

A No, I would not say that the set was a success.

Q38 What was the difficulty?

A The difficulty was that when the automobile went under a bridge or under power lines or underneath overhead trolleys, the volume went way down or else the signal vanished entirely in the case of going under a bridge.

Q39 Does this make automatic volume control important in an automobile set?

A The use of automatic volume control in an automobile set eliminates a large part of that. It cuts down those variations and as soon as there is any signal present at all it will bring it in with practically constant volume.

### *Cross Examination*

By Mr. Philbin:

XQ40 When was the model 95 set put on the market?

A In 1929.

XQ41 Was that the first commercial broadcast set so far as you know that had A.V.C. in it, that was sold commercially?

A There was a previous A.V.C. set on the market, but I do not believe that it was on the market at the time of our introducing the model 95.

XQ42 What company put out that other set?

A I know of one particular company and that was Radio Corporation.

XQ43 Do you know when that first appeared on the market?

A It was probably a year prior, that is, 1928.

XQ44 In this Philco Model 95 set what tubes were controlled by the A.V.C.?



A The bias for the 3-M type 24 tubes were controlled. As you see, this third tube did not have as much bias as the others.

XQ45 But each of the first three tubes had the automatic volume control on the grid?

A That is right.

XQ46 Is this a set of the so-called tuned radio frequency type?

A That is a tuned radio frequency receiver.

XQ47 And each of the first three tubes performed the function of amplifying radio frequency current?

A The radio frequency current fed the second detector.

XQ48 Was there any starting negative bias on the grid of the first tube, that is, when no signal was coming in, was there any negative bias on that grid?

A Yes, there is a negative bias on the type 24 tube.

XQ49 About how much was the negative bias in the absence of signal on the first tube?

A In the absence of signal on that receiver, as I recall, it was about three volts.

XQ50 How about the second tube?

A The second tube had the three volts likewise. In fact, all three RF tubes had three volts.

XQ51 Will you tell me where this negative bias came from, what supplied the energy for the negative bias on the first three tubes?

A The bias was obtained from the drop in this resistor marked 49; the section between point E and ground.

XQ52 Is that a part of the power supply for the set?

A That is a part of the power supply.

XQ53 And is it in the B or anode voltage supply part?

A The total plate current of the receiver is passed



through a resistor which supplies the bias. It is a part of the radio receiver, but it is not part of the filter or the power pack design. It is a part of the radio receiver.

XQ54 Is this negative bias on the grids of the first three tubes dependent upon the plate supply?

A It is dependent upon the total to a small extent. It would vary with that total current, but—

XQ55 It is the plate supply that supplies the energy?

A It is the total plate supply that is supplying that bias voltage.

XQ56 And if there was no plate supply there would be no bias on that tube?

A There would be no bias on the tube.

XQ57 You said something about some of your sets using a sort of a triode arrangement. What kind of a tube do you employ now to perform the A.V.C. detection?

A We use a number of different types of tubes for the A.V.C. detection in our line of the present time. We use the straight diode tubes and we also use the combination diode-triode tubes. As well as that, I believe, there are still some sets using triodes with the grid and plate tied together.

XQ58 In the case where you use a combination diode-triode tube, what does the diode part do and what does the triode part do?

A In the design of that receiver, the engineers designing it wanted to realize some gain from the plate circuit and he designed the receiver so that the signal was applied between the grid and cathode with a high resistance in series so that when you consider just that part of the circuit, it is just a straight diode, as we would use. With the plate he took his audio-frequency energy off through the plate circuit.

XQ59 What is the function that the diode part performs?

A It acted as a rectifier and supplied the negative bias to control the RF stages preceding that.

XQ60 And what did the triode part do?

A The triode part acted as an audio amplifier to amplify the audio-frequency component of the signal and passed it on through the audio system.

XQ61 Did the triode or the diode perform the function of detecting the radio frequency currents and producing audio-frequency currents?

A The diode actually did the detecting, that is, the rectification occurred in the grid circuit.

XQ62 What do you mean by the grid circuit of the diode?

A I am referring to the final transformer leading into the diode, into the RF transformer or IF transformer, and I do not recall which one, but the secondary of that transformer, one side connected to the grid and the other side connected through a resistance by-passed by a condenser to the cathode.

XQ63 Does your company use variable-Mu tubes at the present time with their A.V.C. sets?

A They do.

XQ64 Do they use any other type of tubes for the controlled A.V.C. tubes?

A I cannot say right now whether there are any non-variable-Mu tubes which are controlled or not. There were a year or so ago, but I do not know whether they have been discontinued or not.

XQ65 About what proportion of the A.V.C. sets which have been sold by your company have employed a tuning meter or visual indicator?

A Approximately 30 per cent of our production employed a visual tuning indicator.



XQ66 May I ask, to be certain, does that include your entire production up to date?

A The figures are up to some time this season. What I have been basing a lot of my figures on is the fact that some time this season we passed our seven million mark.

XQ67 But the figures you gave me of about 30 per cent was not merely your present production, but included all?

A That is our past production.

Mr. Philbin: That is all.

*Re-Direct Examination*

By Mr. Adams:

RDQ68 Is Philco a licensee of both Hazeltine and Radio Corporation?

A Philadelphia Storage Battery Company is a licensee of both Hazeltine Corporation and Radio Corporation of America.

By the Court:

Q69 What is the price of a good Philco receiver containing all the best equipment?

A It probably runs from \$175 up.

Q70 You cannot get the best type of receiver under \$175?

A You can get a very excellent receiver in the bracket of \$100.

Q71 With all this equipment?

A We have considered now that A.V.C. must be in all sets having more than four tubes; from five tubes on up we have A.V.C. We have A.V.C. sets selling as low as \$30.

(Witness excused.)

Mr. Adams: Mr. MacDonald.



WILLIAM A. MacDONALD, was called as a witness on behalf of the plaintiff, in rebuttal, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Adams:

Q1 What is your connection with the Hazeltine Corporation?

A I am Vice-President and Chief Engineer of the Hazeltine Corporation.

Q2 How long have you been associated with that company?

A Since early in 1924.

Q3 What was your radio experience prior to that time?

A I have been continuously active in the commercial and scientific phases of radio since 1913 or 1914.

Q4 What has been the general nature of that experience?

A In 1913 or 1914 I was an amateur and later became a professional radio operator. In 1916 I joined the staff of the Western Electric Company and was there located in the physical laboratory.

During the War, or just after the United States entered the War, I joined the Signal Corps of the United States Army as an enlisted man, went to France in the latter part of 1917, and during my Army work was associated with Major Edwin H. Armstrong, a well known radio scientist, in a laboratory known as the Division of Research and Inspection established by the Signal Corps.

The Court: Where?

The Witness: In France.

Q5 What was the work of that division?

A The principal work of that division was the testing of various types of communication equipment for the United States Army. The testing of such equipment included the complete analysis both technical and in the field of British, French and American communication equipment. The purpose of that testing work was to ascertain how well it met the requirements of the American Forces, and to forward reports on such apparatus to the United States, so that appropriate American equipment could be designed to serve the armies in the field.

In addition to that, where there were very pressing problems and equipment that was most urgently needed, the Paris Laboratory developed such equipment with its own staff. In this group there were approximately 75 or 100 specialists in various communication fields, most of whom had been recruited from the laboratories of the American Telephone & Telegraph Company.

Q6 At that time did this section develop the so-called superheterodyne receiver?

A Yes. As a matter of fact, I carried forward the preliminary development work of that apparatus under the direction of Major Armstrong and built the first apparatus of that kind for communication purposes and reception of broadcast signals; not necessarily broadcast signals, but principally airplane signals and enemy signals.

Q7 In the use of radio apparatus by the Allies at that time, was there any problem akin to our modern problem of blasting?

A Yes, there was. To answer that question completely, I will have to explain the conditions that existed at the time. There was in excess of 100 miles of front along which various forces were fighting and it was desirable for the allied armies to intercept messages



from the opposing forces for two purposes. The first purpose was to decode them, to ascertain the nature of the communications, and the second purpose was to locate the transmitting stations geographically for the purpose either of shelling those locations, thus disrupting the communication system or to follow the troop movements along the front.

These transmitting stations were located by a special receiving equipment known as a direction-finding equipment. It consisted essentially of what is known as a loop aerial and a very sensitive amplifier. When the aerial is pointed in the direction of the transmitting station, it will give a maximum signal, or if located at right angles to the signal it will give a minimum signal. By triangulating the directions from two of those receiving stations, the transmitter could be accurately located.

It was therefore essential to copy every character that was transmitted from the opposing forces, and I say that because on many occasions only a few characters were transmitted. These transmitting stations were of varying power and obviously of varying distance from the receiver.

The Court: What were they? What do you mean by characters? You had French, German and English to reduce to a language?

The Witness: Yes. I have principally in mind that the enemy's transmitting stations were located along the front and at army headquarters, and they obviously were at different distances behind the lines. As a matter of fact, most of those transmitting stations had a characteristic which could be easily identified.

The Court: The quality of sound?

The Witness: Yes.



Mr. Davis: I wonder if it should be explained, your Honor, that the transmission was not by voice, but by telegraph signals.

The Court: I see. That was the character.

The Witness: It was entirely by telegraph signals.

The Court: That is a common language?

The Witness: Yes.

A (Continued) Because of the varying distances of the receiving stations from the transmitting stations and because of the varying power of the stations, the signals received at the various receiving stations varied enormously with respect to others. Some of them would be very weak and again some of them would be very strong. The equipment employed by the American, French and to some extent by the British forces was largely French equipment. It consisted of rather sensitive multi-stage amplifiers:

When the operators were receiving these signals—

Q8 When you say "sensitive" how would the sensitivity of those amplifiers compare with the sensitivity of amplifiers in 1925 or even at the present day?

A They were, of course, not nearly as sensitive, compared to the amplifiers we are accustomed to use today, but at the same time they were operated by experts and were reasonably sensitive.

I would guess that their sensitivity might be of the order of 50 or 75 microvolts as compared to 5 or 10 microvolts used today.

The French equipment then in use was such that the output signal at the receiver would vary, of course, in proportion to the strength of the incoming signal in the sense that if the signal was a strong one, a loud output would be received. This was an undesir-

able characteristic in the sense that at that time the operators used head telephone and if the signal was unusually loud it would temporarily paralyze an operator's ears. Consequently, considerable attention was given to the possibility of devising an apparatus which would provide the necessary sensitivity, but at the same time eliminate the blasting effect that was current in all receivers at that time.

Q9 Was a receiver developed which would do this?

A Yes. About the middle of 1918, the British developed a receiver that had accomplished this result in part. It was an apparatus designed by a very well known British engineer, Mr. Round, and consisted of a number of amplifying tubes and included especially a detector system, but principally the detector itself which was designed to provide the necessary sensitivity for weak signals but would readily overload on the stronger signals. Thus an operator could copy without unusually disturbing his routine, you might say, signals of varying amplitude.

The Court: Overloading?

The Witness: That is correct. This amplifier was known as the Round type 55 amplifier and it was fundamentally a limiting system. Its purpose, as I say, was to prevent the unusual fatigue of operators by keeping signals at somewhat the same level.

Q10 When the detector tube overloaded, would it apparently choke off the loud signal?

A Yes, that was the intended function, and it worked in a most satisfactory manner, so far as the telegraph signals were concerned.

Q11 Would it distort the signal in choking it off?

A It would modify the tone of the telegraph signal



somewhat, but would not destroy its fundamental characteristic.

Q12 Would it be a satisfactory sort of thing for a voice telephone?

A No, it would not. Such a receiver would distort it in such a manner that for the relatively strong signals the speech would be practically unintelligible.

Q13 I show you two vacuum tubes and ask you whether you can tell us what they are?

A Those are two vacuum tubes which were used in the type 55 amplifier. They are quite different from the type of tubes used today. The first one is an amplifier tube and there were six of these in the receiver. The second one is the detector tube known as a Q tube. It had all the characteristics of readily overloading with strong signals, the "Q" meaning "quiet tube."

Structurally, the detector tube is considerably different from the amplifier tube.

I happen to have those tubes because at the time this amplifier became available, I was very much impressed with the limiting characteristic, and brought those two tubes back with me as a souvenir. I have had them in my possession ever since.

Q14 Would that solution of the special detector tube be a satisfactory solution today with the problem of blasting?

A No, it would not, so far as telephone conversation is concerned, because of the distortion.

Q15 In fact time in France, in the use of the radio apparatus by the Allies, did you have any problem similar to the present-day problem of fading?

A Yes, we did.

Q16 What was the nature of that phenomenon at that time?

A That problem developed in this way: I was sta-



tioned at one of the large American Airports, and had established a Radio Laboratory there for the purpose of instructing pilots and observers in the use of radio telephone equipment.

At that time I had a group of about 25 engineers, and possibly 15 or 20 airplanes which we attempted to keep continually in operation for instructional purposes. In the reception of radio telephone signals in an airplane (and as a matter of fact in a transmitter too), there is the problem of fading in the sense that the radio receiver located in the airplane, employs as an aerial system, or employed at that time, a long trailing wire, that is, a wire perhaps 100 or 200 feet in length. That wire or aerial had directional characteristics, so that as the plane was maneuvering in the air, the strength of the received signal would vary greatly. For example, as the plane was moving away from the transmitting station, the signal might be very strong. As it was approaching the transmitting station, it might be very weak.

Q17 Is that what you mean by "directional characteristics"?

A That is correct. In other words, the signal voltage picked up on the antenna, varied markedly with the character of the antenna, in the sense of its physical dimensions, and might vary greatly as the plane was maneuvered in the air. In any event, as the operator in the plane attempted to receive signals from the ground, it was necessary to continually be adjusting the apparatus, that is, either the manual volume control, or the tuning member, for the purpose of keeping the signal at a reasonably constant level.

It was necessary to keep it on a constant level, because the operator used head telephones in conjunction with a heavily padded leather helmet, and if the signals

became too loud, the characters would be more or less distorted, and it would be impossible to understand them. On the other hand, if they became too weak, the noise of the engine and the rushing of the air past the observer, would make the signals unintelligible.

Therefore, a volume control system of some kind would have been of very great utility in this class of service.

Q18 Which sort of signals were received?

The Court: Shall we pause here for five minutes?

Mr. Adams: Yes, your Honor.

The Court: The Court will recess for five minutes.

(After a short recess.)

By Mr. Adams:

Q19 What sort of signals were you receiving in the aeroplanes, Mr. MacDonald?

A Mostly radio telephone signals.

Q20 Was this type 55 receiver with its special detector tube a solution to the problem of fading in the aeroplanes?

A No, it was not. The problem of receiving the telephone speech at reasonably uniform level was of sufficient importance and I had been so impressed with the performance of the British 55 receiver that I took one of these instruments, installed it in an aeroplane and conducted a number of experiments to ascertain whether it would be suitable for the reception of telephone signals.

After some work on this along these lines, I found that it was not suitable because of the distortion resulting from the use of the overloaded detector.

Q21 Did you find any solution at that time which was satisfactory?



A No. Even after the experimental work with the British 55 receiver, I attempted to build a special amplifier operating somewhat along the same principles as the British 55 in an effort to solve the problem, but was unsuccessful in developing apparatus that would meet the requirements.

The Court: Armstrong collaborating with you?

The Witness: Yes and no. I will say that in this way: I was in charge of the work at the aviation field and would report to Major Armstrong in the Paris laboratory usually once a week and usually over week-ends. I would come in from the flying field usually on a Saturday afternoon and work with him in the Paris laboratory for the rest of Saturday and over Sunday and go back to the field again.

The problem of fading was a very important one. It was immediately recognized as soon as you listened to a signal in an aeroplane and it would have been of great value if we could have found a solution, but the attempts we made were unsuccessful and we just did not know how to get the results.

By Mr. Adams:

Q22 What was the first time you ever heard of a solution that would have been satisfactory?

A From Mr. Wheeler.

Q23 When was that?

A About the middle of 1926.

Q24 Was that an automatic volume control system?

A That was an automatic volume control system, yes.

Q25 What sort of automatic volume control rectifier did that employ?



A That automatic volume control system employed a 2-element rectifier.

The Court: Was this at the Hazeltine Laboratory?

The Witness: Yes, sir.

Q25 Were you familiar in 1926 and 1927 and 1928, with the problems that confronted the designers of commercial broadcast receivers?

A Yes, I was.

Q27 What were the problems that confronted them in the production of radio receivers?

A There were a number of problems which were very important at that time. In 1925—and I will start a little earlier than your question requires—it was the general custom to employ amplifying systems using two stages of radio-frequency amplification, a detector and usually two stages of audio-frequency amplification.

In an effort to improve the performance of these receivers, it was desirable to secure greater amplification and improve the selectivity. In this respect it was found necessary to add an additional stage of radio-frequency amplification to the type of apparatus then in use, thus making a total of three amplifying stages preceding the detector.

By the addition of this additional stage, it introduced a number of complications. Those complications resulted from a tendency of the apparatus to oscillate, thus requiring a commercial development in shielding, that is, shielding each of the amplifying stages to prevent intercoupling. Additionally, we were at that time working with what may be referred to as simple transformers. Those are the devices which couple one amplifying tube to the succeeding tube. A simple transformer usually consists of a small number of turns of wire which is re-

ferred to as the primary, and a larger number of turns of wire referred to as the secondary. The secondary is usually tuned by a condenser.

This simple type of transformer usually has an amplification characteristic which varies with frequency. It varies with frequency in the ratio such that at the high frequency end of the tuning range at that time, which was about 1500 kilocycles, there would be a given amount of gain, while at the low frequency end of the range there would be about one-third that amount of gain.

The total amplification, that is, the total radio amplification of a receiver, depends upon, or is determined by, the product of the individual gains, that is, the gain of each amplifying stage; so that when we were accustomed to obtain a gain of the order of 7 or 8, at the low frequency end of the range, and about three times that at the high frequency range, and if there were three stages of the amplifier, it would be the cube, that is, the total gain would be the cube of that individual stage gain.

Additionally, there was a gain in the antenna transformer and antenna coupling system, which usually varied in about the same manner. So that the gain of the entire radio frequency amplifier would be roughly equivalent to the fourth power of the individual stage gain.

This, therefore, presented a very difficult problem from the point of view of stabilizing the amplifiers. If sufficient gain was procured at the low frequency end of the tuning band to meet requirements, then the system would be very unstable at the high frequency end of the band. If the gain was lowered so that it would be ample at a high frequency end of the band, then it would be unsatisfactory at the low frequency.

In an effort to solve this problem, a great deal of work was done on what are termed "uniform gain trans-

formers". That is a coupling system which will provide approximately uniform gain over the entire tuning range.

In any event, the industry was confronted first with the problem of increasing the total amplification of the receiver and developing the necessary technique in shielding. They were also confronted with the problem of re-designing the simple transformers we had previously been accustomed to, to a much more complex type, to provide the uniform gain.

And, additionally, it was desirable to obtain as much gain per stage as possible, for at that time, amplifying systems, tubes and other component parts in the receiver, were quite expensive. Therefore, it was desired to accomplish all these results at the minimum cost. So that the industry was attempting to secure the necessary performance characteristics at a minimum cost, and they were occupied in the solution of that problem approximately over the period that you refer to.

Q28 When was the screen grid tube introduced?

A About 1929.

Q29 Did that present any problems in adapting it to radio receivers?

A Yes, there was a special problem that arose there in the sense that although the tube itself was capable of giving considerably more amplification than could be procured with the simple triode, the question of stabilizing that amplifier tube in a multi-stage amplifier, was just as pronounced, if not more so, than had previously been the case. So that probably for the first year's use of that receiver and that type of tube, the problem of stabilization and the prevention of oscillations, was a very serious problem in the sense that small changes, in perhaps line voltage, would cause greater amplification, resulting in difficulties in the field, and



the return of enormous quantities of sets to the manufacturer, because of unsatisfactory operations.

The Court: Who introduced to Wheeler this problem?

The Witness: The problem of automatic volume control?

The Court: The problem of automatic volume control?

The Witness: As far as I know, he realized that it would be an important step forward, an important advantage and conducted the work himself.

Q30 When did the automatic volume control system go into commercial use as a general matter?

A About 1930.

Q31 Did these design problems of the amplifier and the coupling coils and the screen grid tubes, have anything to do with the delay in adopting the automatic volume control system?

A Positively. The designing engineers, the set designer, prior to 1930, had been confronted with so many problems in an effort to develop a suitable receiver, with the technique he was then familiar with, eliminating field troubles, that when these problems had been reasonably solved, he then turned the development to a feature which had been well known to him prior to that, but which he had not been able to attack, because of the other problems that had then been confronting him. In other words, prior to 1930, the question of blasting and the question of fading, was an important one, but it probably was not as important as the matter of producing suitable saleable apparatus that would stay sold over a period of time.

Q32 And that was the problem of designing the amplifier that you have referred to?

A That is correct, taking the troubles out of those amplifier designs.

Q33 Can you tell us, Mr. MacDonald, approximately what the amplification per stage today is in the intermediate stages of the superheterodyne?

A That varies somewhat depending on the design of the superheterodyne. If a single stage of intermediate frequency amplification is employed, the amplification varies or is likely to vary between 60 and 80 or 90. If a two-stage amplifier is employed, the amplification is usually kept at the order of 20 per stage.

The Court: If three be employed?

The Witness: It is not very common to use three of them, but when that is the case, the amplification is usually reduced possibly to the order of 15 or less.

Q34 I call your attention to the radio receiver marked Plaintiffs' Exhibit 14 and ask you when you first saw that?

A Probably a day or so before August 11, 1926.

Q35 I have a photograph here which is Plaintiffs' Exhibit 15 which shows a portion of the panel in the interior of that set and it bears an inscription apparently scratched on the panel "Demonstrated August 11, 1926, W.A.M., H.A.W., M.L.L." Do you know anything about that?

A Yes. The receiver was demonstrated on August 11, 1926, and the initials W.A.M. are my initials inscribed after the demonstration, and the initials below that are the initials of Harold A. Wheeler and the initials below those are Mr. Levy's initials, who has previously testified here.

Q36 Did you put your initials there?

A Yes.

Q37 And did you see the others put their initials there?

A Yes.

Q38 And was that on August 11, 1926?

A It was.

Q39 Reference has been made to a disclosure of this Wheeler automatic volume control system to the I.R.M. Engineers on August 19, 1926. Were you there at that time?

A I was.

The Court: If this advance or improvement had been long sought for by all these producers, why did they not all go over there to the laboratory?

The Witness: I am not sure at what time you mean.

The Court: Is this the time when Mr. Wheeler presented or demonstrated before a bunch of engineers?

Mr. Adams: Yes, your Honor.

The Court: And Clement and Million representing one concern came across?

The Witness: They came over to the laboratory.

The Court: And they were the only ones?

The Witness: I would not say that they were the only ones, but they are apparently the only ones that we have a record of.

The Court: Were you there when they came?

The Witness: I believe so.

The Court: Do you know about the others?

The Witness: I would like to explain that in this way, that the laboratory we maintained at Stevens Institute was a relatively small one. Mr. Wheeler was working there and we had one or two



other engineers and I had occasion to travel a good deal to visit the manufacturing plants of different licensees. For that reason I was absent a good portion of the time.

The Court: Were you there when Clement and Million came?

The Witness: I believe I was.

By Mr. Adams:

Q40 I show you Plaintiffs' Exhibit 13 entitled "Minutes of the August meeting of the I.R.M. Engineers" and ask you if that reports the events of that meeting, as you recall them?

A Yes, it does.

Q41 Did you receive a copy of that at about that time?

A I cannot say. It was customary for Mr. Graham, who was secretary, to forward copies of the minutes to the engineers in charge of the various companies who were in the I.R.M. group, and also those such as Hazeltine Corporation, who may have discussed a particular technical problem. It is probable that a copy of that was forwarded to the Hazeltine Corporation at Hoboken and also a copy was forwarded to Wheeler and possibly the other engineers who were present at the time, although I cannot remember that happening.

The Court: How many concerns were represented at this meeting?

Mr. Adams: I imagine there are about ten or something like that.

Mr. Davis: Seven. There was more than one representative of several of the companies.

By Mr. Adams:

Q42 In this copy of the minutes it states:

"Mr. MacDonald further reported that there had been considerable work done on the variable ratio coupling transformer since Professor Hazeltine's report."

What is this variable ratio coupling transformer?

A. That was the uniform gain coupling system that I referred to a few minutes ago as being a rather difficult, and at the same time important development conducted by the Hazeltine Laboratories.

I might explain, if I may, that it was the custom of the Hazeltine Corporation to hold meetings about once a month with the various members of the I.R.M. These were technical meetings and it was the idea to get together and discuss problems of general interest, and at those meetings to report developments conducted or completed by the Hazeltine Corporation Laboratories. It was a sort of a gathering place of the group, all interested in the same problem, namely, of producing a high class radio receiver.

Q43. In the course of your visits to the factories, did you explain these matters to the engineers in connection with their own apparatus?

A. Yes, that was one of the functions of the laboratory.

Q44. Was there any necessity for the engineer to visit your laboratory in order to get full information concerning your developments so far as they related to his apparatus?

A. Not necessarily, but frequently desirable. It was quite customary for the engineer to send in to the laboratory a particular receiver that he had been having trouble with. We would usually work on it, correct the trouble, and we might return it to his company without his having come to the laboratory. On the other hand,

we may have kept it a few days, made corrections, and then he would visit the laboratory and we would discuss verbally the changes and modifications made. So that both methods were practiced.

The Court: What is the name of this organization?

Mr. Adams: The Independent Radio Manufacturers, Inc.

The Court: The I.R.M.?

Mr. Adams: Yes.

Q45 Was this variable ratio coupling transformer a matter of importance to these radio manufacturers at that time?

A Yes, it was a matter of very great importance, because there had been so much difficulty in preventing overall oscillations, that is, oscillations in an amplifier development between the input and the output, because of the peculiar gain characteristics or amplification characteristics of a simple transformer. Therefore, the Hazeltine Corporation laboratory undertook a development to procure a solution and preferably one whereby the gain was made uniform or could be controlled over the frequency range, and that development lasted possibly for a period of eight or ten months or a year.

Q46 It says here, relating to this variable ratio coupling transformer: "This work was carried on by Mr. Wheeler. He had devised improved circuits with better performance and greater simplicity. He said"—referring to Mr. MacDonald—"that Mr. Wheeler would describe a standard form of this coil and that any variations could be discussed in detail with the laboratory." Is that correct?

A That is correct.

Q47 Do you know whether any of these engineers



came over to the laboratory to see or witness the operation of this improved coil?

A It is hard to remember, but I do recollect that Graham and I believe Mr. Levy of the Stromberg-Carlson Company came over to discuss that matter in detail.

Q48 Were the engineers of the I.R.M. given information on this variable ratio coupling transformer as well as on the automatic volume control at this meeting?

A I believe they were. I might say in addition to that that it was usually customary to prepare reports of one type or another that were forwarded to the engineers.

Q49 What was the first commercial receiver made in substantial quantities, using the Wheeler automatic volume control?

A That receiver was known as the Model 95, and was produced by the Philco Company, the Philadelphia Storage Battery Co.

Q50 Was that a departure from the ordinary practice in commercial receivers?

A It was a decided departure in the sense that it employed a 2-element rectifier and automatic volume control.

Q51 Is there any risk run by a manufacturer in marketing a new type of device of that kind?

A There is indeed; and as a matter of fact, most of the larger manufacturers are very reluctant to produce a new device until there have been a great many tests, especially field tests conducted on it, to be sure that it will not cause trouble and later cause a great many returns.

Q52 Was the Model 95 Philco receiver a success?

A It was in every sense of the word, both from the point of view of performance and from the point of view of the quantity sold.

Mr. Adams: That is all.

*Cross Examination*

By Mr. Philbin:

XQ53 Did you say that in 1925 there was a difficult problem of stabilizing broadcast receivers?

A Not so much in 1925 as in 1926.

XQ54 By "stabilizing", do you mean preventing oscillations, due to regenerative effects?

A Yes; and I have been referring to them here as over-all oscillations.

XQ55 Do you know of the system for preventing oscillations which is described in the Hazeltine patent No. 1,533,858, which is also referred to in the Wheeler re-issue patent?

A Yes.

XQ56 Will that method prevent oscillations and solve the problem of stabilizing?

A Oh, yes. All of those matters, of course, are relevant, and the method of neutralization developed by Professor Hazeltine, accomplished an excellent job, until we began to greatly increase the amplification, and then further refinements had to be made in the sense of eliminating spurious coupling effects; and it took us considerable time to learn how to accomplish the reductions of those minute couplings.

XQ57 Do you mean that the so-called plate circuit neutralization method of stabilizing, was satisfactory, up to 1926, and not after that time?

A It was satisfactory up to, and after that time.

XQ58 Then I did not understand you, because I obtained the impression from you that that method was not sufficient after 1925; was it sufficient after 1925?

A Oh, yes.

XQ59 Then what was this problem of stabilizing which became difficult after 1925?

A I have tried to explain that as the amplification of the receiver was greatly increased over the values we had previously had, that it was necessary to include refinements in the sense of minimizing the minute couplings theretofore negligible, but with the increased amplification they became of importance. Therefore, it was necessary for us to find out how to shield apparatus from a commercial point of view.

Now, when I say commercial point of view, I mean not from a laboratory standpoint, but in such a way that the apparatus could be constructed and sold in commercial quantities.

XQ60 With the increased amplification in the sets of 1926, would this plate circuit neutralization method alone, be satisfactory?

A Yes, if properly practiced.

XQ61 Is that true of the 1927 sets?

A If properly practiced, it would.

XQ62 Then was anything needed after 1925 with respect to this problem of stability other than this plate circuit neutralization method, which was known as of that time?

A May I have that question? (Question repeated.) I do not think there was, if the necessary precautions were taken. It was a matter of procuring experience and ascertaining just what was important, and the things that had to be "respected"; you might say.

XQ63 You referred to a variable ratio coupling transformer; was it necessary to use such a transformer to accomplish satisfactory results of stability, if the plate circuit neutralization method were employed?

A Not essentially, but very desirable.

XQ64 Do you know whether or not this variable ratio



coupling transformer matter is described in the Wheeler re-issue patent?

A I do not think it is.

XQ65. You testified, I believe, that the automatic volume control came into commercial use about 1930. When did the screen grid tube come on the market in substantial quantities?

A I believe the year before that, 1929.

XQ66. And you testified that there were some problems connected with the use of the screen grid tube in broadcast receivers. Were there any such problems in 1926, 1927 or 1928, that is, there was no problem about using screen grid tubes before they came on the market?

A No, except that there is nothing unique in the screen grid tube itself, in the sense that it is simply a device which will provide somewhat more amplification than was possible to procure with the conventional triode used prior to that.

Therefore, the problem in 1929 when screen grid tubes became available, was precisely the problem that was presented just before that, with triodes in attempting to procure greater amplification.

XQ67. About how many members were there of the I.R.M.T?

A I have not checked that up for many years, but I believe there were perhaps 12 or 14; I can check it, if you like.

XQ68. Were those 12 or 14 members manufacturers of broadcast receivers who were licensed under the Hazeltine Corporation patents?

A Yes.

XQ69. Did those licensees have the right to use automatic volume control under the Hazeltine patents, without the payment of additional royalty?

A I do not know what you mean by additional royalty. As I recollect it, the license that they had included a license under the issued patents and pending applications.

XQ70 That is, if they used an automatic volume control, they would not have paid anything more, would they?

A No.

XQ71 The royalty was so much per set under any and all patents they might wish to use?

A That is my understanding.

XQ72 During 1926 and after this August meeting of the I.R.M. and during 1927 and 1928, did you visit the manufacturing plants of the Hazeltine licensees?

A Well, it was my custom to travel a good deal, and I will certainly say that I did, although I have no specific situation in mind.

XQ73 Did the screen grid tube have anything to do with the failure of these Hazeltine licensees to use automatic volume control in 1926 or 1927?

A May I have that question? (Question repeated.) I do not think the screen grid tube was available until 1929, although one form of it was available prior to that.

XQ74 So screen grid difficulties had nothing to do, had they, with the matter of the question as to whether Hazeltine licensees used automatic volume control up to at least 1929?

A I think that is probably true. When the tube became available, they had so many problems in attempting to stabilize the amplifiers that it took them a year to solve those problems.

XQ75 Did the Philco 95 have screen grid tubes?

A Yes.

XQ76 That was in 1929?

A I would have to check it, but I think it was 1930. I am not positive.

Mr. Philbin: That is all.

*Re-Direct Examination*

By Mr. Adams:

RDQ77 Were the Hazeltine licensees in 1927 also licensed by the Radio Corporation of America?

A Yes.

RDQ78 Were they licensed by the Radio Corporation of America to make superheterodyne receivers?

A In what years?

RDQ79 1927?

A They were not.

RDQ80 When were they first licensed to make superheterodyne receivers?

A I believe it was 1931.

RDQ81 Did the licensees make tuned radio-frequency receivers or superheterodyne receivers prior to the time that they were licensed to make superheterodyne receivers?

A They made tuned radio-frequency receivers.

RDQ82 Was the oscillation problem more or less acute in superheterodyne receivers or in tuned radio-frequency receivers?

A The oscillation problem was more acute in tuned radio-frequency receivers.

RDQ83 Do you know whether or not there were any radio manufacturers in the United States licensed to use the super-heterodyne receiver prior to the time that the Hazeltine licensees were licensed to do it?

A As far as I know, I do not believe there were any other than the Radio Corporation licensed to manufacture under the superheterodyne situation for broad-



cast reception. There may have been conditions involving communication with which I am not familiar.

Mr. Adams: That is all.

*Re-Cross Examination*

By Mr. Philbin:

RXQ84 Was there an oscillation problem in 1927 with tuned radio-frequency amplifiers?

A Yes, that applied from 1927, and including the period up to 1929.

RXQ85 And by "oscillation problem" you mean the prevention of oscillations due to the regenerative action?

A Yes.

Mr. Philbin: That is all.

(Witness excused.)

"IT IS STIPULATED that WALTER A. MacNAIR, if called, would testify as follows:

I am at present employed as an engineer in the Bell Telephone Laboratories in New York City.

In 1925 I was a National Research Fellow in Physics at Johns-Hopkins University in Baltimore, and there became acquainted with Harold A. Wheeler, who was also taking post-graduate work.

"During the Christmas holidays in 1925 I attended a party at the home of Harold A. Wheeler in Washington, D. C. This was on January 3, 1926. During the party Wheeler took me and two other guests, F. M. Defandorf and Vernon E. Whitman, down to the cellar of his home to witness a demonstration of a new radio receiving set that Mr. Wheeler had developed.

I remember that the apparatus was spread out over a large table and that it had very prominent shielding cans. I do not now remember any of the parts of the apparatus or any of the wiring. I have examined the apparatus (which is now Plaintiffs' Exhibit 19) and can state that it generally resembles the apparatus which I saw at that time in Mr. Wheeler's home.

I remember that the demonstration showed that a distant station, which might have been as far away as Chicago, and nearby station, such as Baltimore, were brought in with substantially the same intensity. I do not recall any of the details that might have been discussed at that time except that I recall that Wheeler stated that the automatic amplification control operated by feeding energy from the later part of the set back to the earlier part, and I remember that it sounded very mysterious to me.

"At the time of the demonstration I signed a page in Wheeler's notebook and so did Messrs. Defandorf and Whitman. There was some mistake made in entering the date. Defandorf, Wheeler and I put the date down as 1925. When Whitman came to sign he called our attention to the fact that it was now a New Year and should be 1926. The name 'Walter A. MacNair' appearing on page 94 of Wheeler Notebook No. 6 is my signature and was placed there by me at that time. The other signatures 'F. M. Defandorf' and 'V. E. Whitman' were also signed at the same time. The statement just above the three signatures, namely, 'Jan. 3, 1926—Demonstration of 'Audiostat' or 'Amplistat'—An 8-tube Superheterodyne-neutrodyne set with automatic volume regulation' was placed there by Wheeler immediately below the four circuit diagrams before we signed and dated the page."

"IT IS STIPULATED that F. M. DEFANDORF, if called, would testify as follows:

I am employed as a Physicist in the National Bureau of Standards. I have been employed at the National Bureau of Standards since June 1, 1916, except for periods of college and post-graduate residence study.

I became acquainted with Harold A. Wheeler when we were both taking post-graduate work at Johns-Hopkins University in 1925. Both Vernon E. Whitman, who roomed at Johns-Hopkins with Wheeler, and I were in the Bureau of Standards in 1925 and also were taking post-graduate work at Johns-Hopkins.

Shortly after New Year 1926, I attended a party at the home of Harold A. Wheeler in Washington, D. C. During this party Mr. Wheeler asked Whitman, Walter MacNair and me to witness a demonstration of a new radio set which he had developed. I distinctly remember



the demonstration of the automatic volume control feature of this set, as the idea was entirely new to me on that occasion. I remember the apparatus was spread out over a table and was in the form of a so-called 'bread board' set up. I also remember the prominence of the shielding in the apparatus. I also remember the improvement with which KDKA, a Pittsburgh station, and WGY, a Schenectady station, were received. They came in at nearly the same volume as WCAP, which was a local station. KDKA, the Pittsburgh station, was notorious in Washington in those days for fading during reception.

"I have examined the radio receiver (Plaintiffs' Exhibit 19) and although I cannot positively identify all of the details of the set illustrated in the photograph as being the one which was demonstrated in Mr. Wheeler's home in January of 1926, I can say that the set in many respects looks to be the same set.

At the time of this demonstration in Mr. Wheeler's home, Whitman, MacNair and I signed our names in Wheeler's notebook and placed the date opposite our names. We signed the book immediately below a statement which was written by Mr. Wheeler. I have examined a copy annexed hereto of page 94 of Wheeler's notebook. The name 'F. M. Defandorf' and date 'Jan. 3, 1926' were placed there by me on that date. The date was first written 'Jan. 3, 1925,' but when Vernon E. Whitman signed he called our attention to the fact that we had all forgotten that the date had changed from 1925 to 1926. The other signatures were placed there at the same time that I wrote mine. Before we signed our names in the book Wheeler wrote the statement which appears immediately below the circuit diagrams and above our signatures."

"IT IS STIPULATED that VERNON E. WHITMAN, if called, would testify as follows:

I am at present employed as a radio engineer by Hazeltine Corporation.

I have been intimately acquainted with Harold A. Wheeler since about 1924, at which time we both lived in Washington, D. C.

In 1925 we occupied the same rooms in the dormitory at Johns-Hopkins University at Baltimore, Maryland, and attended the same courses in the Physics Department.

"In 1925 and 1926 I frequently discussed radio and electrical subjects with Mr. Wheeler.

On December 18, 1925 I wrote my initials and the date on pages 77, 78, 79, 80, 83, 84, 85 and 88-90 inclusive of Wheeler's Notebook No. 6.

On the evening of January 3, 1926 I attended a social gathering at the home of Harold A. Wheeler in Washington, D. C. During the course of the evening, I, in company with two other guests, namely, Mr. Walter A. MacNair and Mr. F. M. Defendorf, were shown by Mr. Wheeler an improvement in radio receiving devices. The apparatus was located in the basement of Wheeler's home, where he was conducting electrical experiments. At the time of the demonstration Wheeler referred to the device as an 'Audiostat,' and stated that its function was to automatically control the radio frequency amplification in accordance with the strength of the incoming signal, so that the output would be nearly independent of signal intensity.

At the time of the demonstration the automatic volume control was demonstrated both orally and visually. The visual demonstration was accomplished by means of a Weston Model 280 meter whose deflection varied with the signal intensity while the loud speaker output re-

mained nearly constant. The reception of KDKA of Pittsburgh, Pennsylvania, which was famous for its fading in Washington, D. C., was very good. KDKA gave practically constant speaker output, while the deflection of the Model 280 Weston meter changed substantially from time to time. Another feature of the set which was demonstrated at this time was its ability to prevent local stations from blasting in the loud speaker when the set intensity was adjusted for distant reception.

"After the demonstration, Mr. MacNair, Mr. Defandorf and I signed on page 94 of the Wheeler Notebook No. 6. The three of us signed our names under a statement which Wheeler wrote in the book, namely, 'Jan. 3, 1926 Demonstration of 'Audiostat' or 'Amplistat', an 8-tube superheterodyne-neutrodyne set with automatic volume regulation.' Mr. Wheeler, Mr. MacNair and Mr. Defandorf all wrote the date as '1925' instead of 1926, and then changed the date after I called their attention to the fact that the year had just changed from 1925 to 1926.

"The apparatus which has been identified in this case as Plaintiff's Exhibit 19 very closely resembles the apparatus which Wheeler demonstrated to us at that time at his home in Washington. I cannot be positive as to all the details of the wiring after a lapse of so many years, but I can say that it looks generally like the receiver that was demonstrated at that time and that I have never seen any other receiver that looked like it."

"IT IS STIPULATED that JOHN F. DREYER, JR., if called, would testify as follows:

I was graduated from Stevens Institute of Technology in 1921 and the following Fall became instructor at Stevens in Electrical Engineering. In 1922 I entered



the employ of Professor Alan Hazeltine as a radio engineer in the development of radio broadcast receivers. After Professor Hazeltine sold his interests in the radio receiver development to Hazeltine Corporation I entered the employ of that company in the Spring of 1926 and shortly thereafter entered the employ of Atwater Kent Manufacturing Company as a radio engineer and continued there until my present employment by RCA Manufacturing Company, Inc.

"In July 1925 Harold A. Wheeler was in the employ of Hazeltine Corporation and was working with me at the laboratories of that company in Hoboken, New Jersey. It was Mr. Wheeler's practice at that time to keep a notebook in which he entered radio circuits, tests and computations which related to the work in which he was engaged. It was also his practice to have the various pages witnessed and dated by others.

I have examined Wheeler Notebook No. 6 and have observed my signature 'J. F. Dreyer, Jr.' one or more times on each of the following pages:

14	Aug. 18, 1925
15	Aug. 18, 1925
17	Aug. 18, 1925
32	Aug. 18, 1925
77	Apr. 5, 1926
78	Apr. 5, 1926
79	Apr. 5, 1926
83	Apr. 5, 1926
84	Apr. 5, 1926
85	Apr. 5, 1926
86	Apr. 5, 1926
88	Apr. 5, 1926
94	Apr. 5, 1926
96	Apr. 5, 1926

"These signatures are in my writing and were placed there by me on the dates written in each case by me in proximity to the signature. I do not now recall the exact contents of each page at the time I signed and dated each page, but I know that each page did at such time have on it some matter relating to radio developments on which Wheeler was working, and I have no reason to believe that any page is any different now than it was at the time I signed it. It was Wheeler's custom to explain the subject matter of each page to me when I signed my name.

In one case I did more than sign the page. On page 94 I wrote opposite four circuit diagrams on that page 'Demonstrated to me on 4/5/26.' This was the date on which Wheeler demonstrated to me at his home in Washington his so-called 'Audiostat' receiver, which employed a system of automatic volume control developed by Wheeler. I have recently examined the apparatus Exhibit 19, and although it looks to me like the receiver that Wheeler demonstrated to me on April 5, 1926, I cannot be sure that in all details it is now in the same condition as it was then. I do not remember the circuit of the receiver demonstrated to me at that time, but the entry on page 94 of the notebook just referred to makes me believe that the circuit shown on page 94 was the one demonstrated to me at that time.

"Wheeler had written to me on December 15, 1925 saying that he hoped to be able to build his automatic volume control receiver during the Christmas holidays. Exhibit 24A is the letter I received at that time and Exhibit 24B is my reply to that letter.

"On April 14, 1926, after Wheeler demonstrated his receiver to me, I wrote a report to Mr. Pierson, President of Hazeltine Corporation, commenting on the dem-

onstration. Plaintiffs' Exhibit 25 is the report I then wrote."

"IT IS STIPULATED that W. H. TAYLOR, JR., if called, would testify as follows:

"I am a member of the firm of Pennie, Davis, Marvin and Edmonds, counsel for Hazeltine Corporation, and have been ever since prior to July of 1925.

In 1925 Harold A. Wheeler was in the employ of Hazeltine Corporation and occasionally he asked me, as patent counsel for the company, to sign and date pages of his notebooks relating to radio developments on which he was working. It was his practice to explain the contents of each page to me at the time I signed it.

I have examined Wheeler Notebook No. 6, and have observed my signature 'W. H. Taylor, Jr. on pages 14, 15 and 17. I wrote my name on these pages at the same time that I wrote the date in proximity to my signature. I do not recall the exact contents of each of these pages at the time I signed my name, but it was my custom to sign my name in a position on the page which as nearly as possible was immediately below the subject matter which at that time was on the page. I have no reason to think that any of the pages on which I signed my name are any different at the present time than they were at the time I signed them."



## PLAINTIFF'S EXHIBIT 27

## STIPULATION

It Is Hereby Stipulated by and between counsel for the parties hereto that the testimony of HARALD TRUP FRIIS, a witness called by RCA Victor Company, Inc. in the case of RCA Victor Company, Inc. vs. Hazeltine Corporation, Equity No. 1071, in the United States District Court, District of Delaware, and the stipulated testimony of H. E. Overacker, Abel G. Jensen, L. M. Clement and Ralph Bown in that cause which testimony appears at pages 663-713 inclusive, and page 1222 of the type-written transcript of the record in that case and a copy of which is hereto annexed with related exhibits, may be offered by either party in this case with the same force and effect as though the witnesses personally appeared and testified, subject only to such objections as might be made if the witnesses appeared personally and testified.

The annexed photostatic copies of exhibits (the originals of which were offered in connection with said testi-

mony) covered by the stipulation are Defendant's Exhibits 9 and 9-A, and photographs of Exhibit 9-B.

Pennie, Davis, Marvin &  
Edmond

By R. M. Adams,  
Counsel for Plaintiff,  
Darby & Darby,  
Floyd H. Crews,  
Counsel for Defendant.

Dated: October 19, 1939.

The Exhibits referred to in this stipulation are reproduced in this record at pages 1379 to 1403.

HARALD TRUP FRIIS, was called as a witness on behalf of the defendant, and having been first duly sworn, testified as follows:

*Direct Examination*

By Mr. Philbin:

Q1 What is your name, residence and occupation?

A My name is Harald Trup Friis; my residence is in Rumson, New Jersey; my occupation is Research Engineer.

Q2 Are you the patentee of the Friis Patent No. 1,675,848?

A Yes, I am.

Q3 Have you a copy of that patent with you?

A No.

Q4 I hand you a copy of that patent. The application was filed in 1924. Will you tell us with what company you were connected in the latter half of 1923?

A Western Electric Company.

Q5 And where were you then located?

A At Cliffwood, New Jersey.

Q6 What were your duties at that time?

A My duties were to do research work in connection with radio receiving. Especially at that time, my duty was to develop a receiving set in connection with a ship to shore circuit.

Q7 What had been your technical education and experience by the last half of 1923?

A I graduated from the Royal Technical College in Copenhagen in 1916, came to the United States in 1919 and studied under Professor Morecroft at Columbia University for one year. After that I entered the Western Electric Company and had up to the time, 1923,

been connected with research work in radio receiving circuits and antennas.

Q8 When you were down at Elberon, New Jersey, in the last half of 1923, what kind of a radio receiver were you working on; that is, what was this receiver to be used for?

A Excuse me, I was not down at Elberon during the last half of 1923, but was located at Cliffwood and only occasionally went down to Elberon during that time.

Q9 What was the purpose of this receiver; that is, what was it to be used for?

A That was to enable telephone subscribers in the United States to talk with passengers on ships at sea.

Q10 That is so that some one on board a ship could telephone to New York or Wilmington?

A That is right.

Q11 And the receiver was to receive the radio waves from the ship?

A That is correct.

Q12 What kind of a receiver was this; that is, was it of the superheterodyne or double detection type?

A Yes, it was of the double detection type.

Q13 Referring to your patent, does it show a superheterodyne receiver?

A It does.

Q14 About when did you first commence working on this receiver?

A In the fall of 1923.

Q15 Have you written records of your work on the development of this receiver?

A I have.

Q16 I show you a note book which on the outside cover has the words "Physical Research Laboratory 1153", and in the upper lefthand corner the initials



"H.T.F." Does this note book contain any reference to that receiver?

A, It does.

Mr. Philbin: I may state to your Honor that on Saturday, I furnished counsel for the plaintiff with photostats of the note book, and they have examined those pages upon which we will rely, as well as looked at the remainder of the book, and also at the set to which reference will be made, that being, I find, more convenient than first bringing it into Court with an opportunity to examine it.

Q17—On page 106 of this note book there is a date of October 3, 1923, and the words, "Automatic Const. Output Gain Control of Receiving Sets. An experimental study of this was suggested by me in the beginning of August to Mr. Bailey."

And then, "The gain control may be done in the following ways."

What was "(1) Gain control of intermediate frequency amplifier"; and I will ask you to read the following words?

A—Section 2:

Q18 No. In Section 1 continuing?

A "(For instance, by changing the negative grid voltage as was done in the 1920 Elberon set or by changing number of stages used, etc.)"

Do you want me to read the whole page?

Q19 No. What is meant by gain control of the amplifier tube by changing the grid bias?

A It means to change the amplification of that amplifier tube.

Q20 What relation has the bias or voltage on the grid to amplification in an amplifier tube?

A As you increase the negative bias of an amplifier tube, the gain of the tube drops.

Q21 Did you know that in 1923?

A I did.

Q22 Now, there are two other methods which you suggest. Will you tell us why you wanted to use automatic gain control in this receiver?

A This receiver was built for reception of signals from ships. The signals you received from ships would vary as the distance to the ship changed, which would mean that you would have a man, an operator in attendance on the set all the time, if you did not have an automatic gain control.

Q23 So the purpose was to eliminate an operator at the receiving set, who would be varying the amplification to accord with the stronger or weaker signals from different ships?

A That is correct.

Q24 I see here a radio receiver. Will you tell us whether that was the radio receiver which you constructed and operated in 1923 and 1924, in New Jersey?

A That is the radio receiver.

Q25 Are the lower two panels which have apparatus in them, are those the superheterodyne receiver itself?

A Yes.

Q26 What is the top panel?

A That is the special equipment we provide to keep automatic gain control in the receiver.

Q27 Was a part of the receiver tapped so as to provide energy for the automatic gain control system?

A Yes.

Q28 What is the tube in the upper panel at the extreme left, what did that do?

A That amplified the signal.

Q29 And what did the tube at the right in the upper panel do?

A That rectified the signal.

Q30 And then what happened to the rectified signal?

A That was used to control the gain of the first high frequency amplifier stage in the main receiving set below.

Q31 And the purpose of this automatic gain control as I understand it, is so that an operator was not needed at this receiver to manually change the amplification, as stronger or weaker signals were received?

A That is correct.

Q32 On page 106 of your notebook, the same page to which you have referred, there is the statement about the middle of the page at the right, "Tube control alone, Scheme 2." What does that mean?

A That meant that we intended to control the gain by means of vacuum tubes only.

Q33 In the circuit diagram at the left does that show a system in which a signal could come in at the left and then be detected and then amplified by intermediate frequency amplifiers and then detected to audio or telephone currents?

A It does.

Q34 And what does the connection at the point A and the line going down and to the left mean?

A That indicates some link between the point A and the gain control of the amplifier for the beating oscillator.

Q35 Will you read the words underneath that sketch?

A "The detector plate current thru A regulates the beating oscillator amplifier (log. change) so that the current only varies between say 150 and 200 micro-amperes (corresponding to say 1000 and one times amplification)."



Q36 What does 1000 and one times amplification mean?

A The amplifier gains change in the relation of one to 1000.

Q37 What does the following sentence mean, and will you please read it?

A "With no time lag in the circuits and an exponential change of the control the scheme will reduce sparks and static, etc."

Q38 What is meant by "exponential"?

A As used here it is kind of used in a loose way. We have different kinds of amplifiers. You might have an amplifier that gives linear gain and you might have an amplifier which gives an exponential gain. It means as you change your adjustment linearly, then you get an exponential change in gain.

Q39 Does that mean that one amplifier will amplify at the same rate, whether the signals are strong or weak, while the other amplifier will amplify stronger signals at a different rate than weaker signals?

A Not as that is understood here.

Q40 In this sketch is the same detector used both for purposes of changing the high frequency current into audio frequency currents and for producing the A.V.C. energy?

Mr. Davis: I object to that. I have not objected to this somewhat leading form of Mr. Philbin's question, because it seemed that so far it was a matter about which there would be no dispute, but I do object to the leading form of this question.

The Court: Does the detector perform a double function?

Mr. Philbin: Yes, your Honor.

Q41 Does the detector perform a double function?

A According to this sketch, yes.

Q42 What is that double function?

A To detect the audio-frequency, so you can listen to the signal and to use the variable rectified detector current to regulate the gain control.

Q43 Have you a memorandum dated February 20, 1924, which describes this receiving set?

A I have.

Q44 Does that memorandum say anything about automatic gain control?

A It does not.

Q45 But it merely describes the receiver without that particular feature?

A That is correct.

Q46 Turning now to your notebook again and to page 121, dated February 28, 1924, will you read the words underneath the date?

A "Automatic gain control of the Elberon receiving set was tried Feb. 26-27-28. The circuit was as follows:"

Q47 And then there follows a schematic circuit?

A Yes.

Q48 In that circuit there are the words "low freq. det." Does that mean the tube that produces the audio-frequency or signal currents?

A That is correct.

Q49 What is the connection in the input side of that tube going down to the indicated tube? What is that for? What does the tube system underneath the low frequency detector do?

A The grid of the tube underneath the tube marked low frequency detector tube is part of an amplifier.

Q50 What is the tube marked B and what is the tube marked A? What do they do?

A The tube marked A is an amplifier tube and amplifies the signal currents. The tube marked B is a detector tube and it detects the signal current.

Q51 Are those two tubes A and B the tubes to which you have referred in describing the automatic gain control in the top panel of the set?

A Yes.

Q52 And is there a connection from the tube marked B around to another system at the extreme left?

A Yes, there is.

Q53 Is this same diagram or arrangement shown more fully in your memorandum of April 14, 1924, Figure 2?

A It is.

Q54 In that circuit arrangement, in Figure 2, at the left is the word "loop." Was that used to receive the radio waves?

A It was.

Mr. Davis: May I interrupt again? Why should not Mr. Friis describe this diagram in his own words rather than have Mr. Philbin do it?

Q55 Will you describe the operation of this system very generally?

A I will. The signals are received on the loop which again is tuned by a condenser. The resulting voltage obtained across the loop is applied to the grid of a high-frequency amplifier. Going from that grid towards the right you pass one intermediate frequency detector, a filter and an intermediate frequency amplifier and finally you apply the signal to the grid of the low frequency detector. In parallel to the grid of this low frequency detector is down below a grid of an amplifier tube which on the diagram is marked "V tube," and going to the left from the tube you see an intermediate



frequency transformer marked 83-A that connects the plate circuit of this tube to the grid circuit of the following V tube, that is, in this case used as a rectifier.

The rectified current of this tube passes over the resistance R shown on the left and the voltage across this resistance R is used as a grid bias of the high frequency amplifier tube above.

Q56 What effect does this grid bias have upon the operation of the set?

A As the signal increases, you get more rectified current through the resistance R. That will reduce the grid bias on the high-frequency amplifier tube and thereby lower the gain of the set. That is, you have a feedback action that tries to keep the output of the set constant.

Q57 Turning to Figure 4 accompanying that memorandum, will you tell us what that means?

A That is a curve that shows the relationship between the voltage input to the grid of the high frequency amplifier and the voltage output on the grid of the low frequency detector.

Q58 What does it mean as a practical matter?

A As a practical matter it means that when you change the input volts from .001 volts to 1 volt, that is a thousand times, you have only a very small change in output voltage.

Q59 Does that mean a difference of a thousand times strength in the incoming signals will make a difference of less than 10 per cent. in the volume of the sounds heard by the listener?

A It does. Pardon me, may I answer further? It means that the input voltage to the low frequency detector changed less than 10 per cent. The sound heard by the listener changed 20 per cent. because we used a low frequency detector in this particular set.

Q60 Have you a sketch dated May 20, 1924?

A I have.

Q61 Will you please describe—

The Court: May 20th?

Q62 Yes, your Honor. Describe very generally and simply the operation of that system.

A This sketch shows an amplifier made up of three tubes marked Nos. 1, 2 and 3. The output of this amplifier is connected to the grid of the rectifier tube, and the rectified current in the output of this rectifier tube is used to automatically gain control the amplifier stages marked 2 and 3.

Q63 What was the value of that resistance R in the output circuit of this rectifier tube, was it small or large?

A It was in the general order of thousands of ohms.

Q64 In your memorandum of April 14, 1924, you state:

"In the case of automatic control, the rectified output current of the receiving set is passed through a large resistance."

What did you mean by "large resistance?"

A The actual resistance used in this receiver was around 20,000 ohms.

Q65 Will you state whether the resistance as used in these other systems to which you have referred in the output circuit of the rectifier tube, were small or large, and about their values?

A As we looked at them at that time, we would call them large resistances.

Q66 Does large resistance mean the same as high resistance?

A Yes.

Q67 Have you any reference on page 136 of your

note book under the date of June 10, 1924, to automatic gain control?

A I have.

Q68 What does the first circuit diagram show with respect to automatic gain control, if anything?

A It shows nothing with respect to automatic gain control.

Q69 Then what about the second diagram on that page. Will you please describe it generally?

Mr. Davis: What are you referring to?

Mr. Philbin: Page 136.

A The second diagram shows a special attachment that we made to this Elberon receiving set, in order to be able to receive short waves. In effect, we changed the set from a double detection set to a triple detection set.

Q70 Is there any automatic volume control shown in that system?

A No.

Q71 Now, will you please read the words between those two diagrams:

A "The 60 cycles introduces losses in the loop corresponding to a variation of field strength of 60 cycles. When the constant output attachment did not work, then the quality of WEAF was very bad and sounded just like KDKA short waves. When the constant output worked, then the quality became good again (4 microfarad and 12,000 ohms times constant), which shows the set can follow 60 cycles changes in field strength."

Q72 Were WEAF and KDKA broadcast stations at that time?

A WEAF was a broadcast station at that time.



KDKA on short wave I believe was used for broadcasting too, although I am not quite sure.

Q73 What is the substance or meaning of those words which you have written there?

A The meaning is that the automatic gain control was so fast that it could follow the change of signal strengths.

Q74 On page 137 there are a few words; is there any reference there to automatic gain control?

A No direct word.

Q75 What does it describe?

A It refers to some listening tests that we made with the automatic gain control set.

Q76 Referring again to page 121, and to the circuit diagram shown there, what was the coupling or connection between the tube A and the tube B?

A A transformer.

Q77 Is that transformer shown in the upper panel of the set?

A It is.

Q78 Which is it?

A This little square box here.

Mr. Davis: Will you be able to identify that on the record?

Q79 Was there any sharply tuned circuit or selective circuit in the automatic gain control system which was employed in the set?

A No.

Q80 In your patent there is shown in the automatic volume control system at the lower righthand corner a condenser marked 13 and a coil marked 14. Was such a coil and condenser used in your set?

A Do you mean the experimental set we have been looking at?

Q81 Yes.

A No, it was not.

Q82 Was such a coil and condenser described in your notebook or memoranda?

A No, it was not.

Q83 Do you know why in the patent there is such a selective circuit and there is none in the receiver that you worked with?

A That was inserted in the patent to make it a little more general.

Q84 Will you tell us a little bit more as to what you mean by making it a little bit more general, the putting of this additional feature in the application?

A As I recollect it, this memorandum that we looked at before marked "Memorandum of April 14, 1924," was the memorandum sent to our Patent Department for patent consideration at that time. What usually happens is that our patent lawyer looks through related art or related patents and after a search like that he calls us in for conference to discuss what we actually should include in the patent.

You will notice that in the patent diagram we have two high-frequency amplifier tubes instead of one, as we used it in our actual experimental set-up.

Also we have a switch that could change the beating oscillator input from entering directly into the loop and to entering directly on the grid of the first detector. We did not have a switch like that on our first experimental receiver.

Also we have inserted the selective circuit marked 13-14, which was not shown or used in our regular tests. Would you repeat your question?

(Last question repeated as recorded.)

A (continued) That particular feature of cutting out these side bands as compared with the carrier will give

an improved automatic gain control action in the receivers, as we used them.

Q85 In the set to which you have referred there are at the back of the middle panel various holes. What were they used for?

A They are jacks, ordinary telephone jacks. They were used to measure the plate currents of the different tubes.

Q86 What did you use to measure the plate currents of these different tubes?

A Meters.

Q87 Tuning meters?

A We did not call it a tuning meter. We called them ordinary ammeters, micro-ammeters, but we used them for tuning purposes.

Q88 Had you ever used a meter for tuning purposes before 1923?

A To my recollection we used only tuning meters for tuning purposes even down at Elberon back in 1920, the beginning of 1920.

Q89 Was a meter a common thing to use for tuning purposes in the radio business as you know it?

A I do not believe so. We used it in our own radio business.

Q90 Beginning when, about?

A Ever since I entered the company which was at the end of 1919.

Q91 What kind of a detector for this automatic gain control did you employ? Was it a diode or a triode?

A It was a triode.

Q92 Did it have an A battery, a B battery and a C battery?

A Yes.

Q93 Did you know anything about diodes in 1923?



A I did.

Q94 Did you ever use a diode instead of a triode for the automatic gain control?

A Not at that time.

Q95 Why not?

A The triode gives more gain than a diode, and at that time we needed gain.

Q96 What is the purpose of the so-called A tube in the automatic gain control system?

A To amplify the signal still further than it was normally amplified in the receiver.

Q97 What happened to this Elberon receiver? Did it go into actual commercial use?

A It did not.

Q98 How long was it used in this experimental work, approximately?

A Approximately to the end of 1924.

Q99 And then what happened to it?

A We put it in storage.

Q100 Do you know whether or not the Telephone Company used this automatic receiver system for getting telephone messages from ships at any time after 1924?

A They use it now.

Q101 About when did they commence using this automatic receiver system for getting messages from ships?

A That would have been either in the fall of 1929 or the beginning of 1930.

Q102 Does that receiver or do those receivers employ automatic gain control?

A They do.

Q103 With what kind of radio waves are these receivers today used, that is, are the waves high or low or short or long?

A Short, as we use the word.

Q104 What kind of waves did you use this 1924 receiver with?

A Comparatively long waves. We actually used that receiver on broadcast, tested it on broadcast waves.

Q105 And broadcast waves are comparatively long as compared with the short waves that are being used today in telephone conversations across the Atlantic?

A Yes, except for one channel that they have across the Atlantic that employs very long waves.

Q106 Will you tell us about what these long waves are and short waves are in terms of meters?

A The wave lengths of our long wave circuits that we use across the Atlantic are approximately 5,000 meters. The wave lengths used in ordinary broadcast as we all know are between 600 and 200 meters. The wave lengths of the signal used in short wave work call for 100 meters and down to about 13 or 14 meters.

Q107 Does this difference in wave length have anything to do with automatic gain control?

A In so far as you are more in need of automatic gain control of short waves than you are of very long waves, it does.

Q108 In 1924 and 1925, when you were working with this receiving system were the ships equipped with short wave transmitters generally?

A No, they were not.

Q108 Today are such ships as the Queen Mary and other ships from which one can telephone to shore equipped with short wave transmitters?

A They are.

Q109 Will the short waves carry further than the long waves?

A That is a very broad question to answer directly. The very long waves that the stations use carry all over

the earth, just as well as the short waves will carry all over the earth.

Q110 Did you have any time constant or time delay or time lag in this receiver?

A In the automatic gain control circuit, yes.

Q111 About what was it?

A A simple condenser resistance, a simple parallel condenser resistance circuit.

Q112 And about what delay did that give, one-tenth of a second or three seconds?

A We tried the different values ranging all the way from a very short time constant to maybe three or four seconds.

Mr. Philbin: That is all.

Mr. Philbin: Defendant offers in evidence as Defendant's Exhibit 9, the notebook referred to by the witness, requesting permission to introduce, in lieu of that notebook, photostat copies of the pages referred to by the witness, and also including the memorandum referred to by the witness, as Exhibit 9-A, and the radio set referred to by Mr. Friis, as Defendant's Exhibit No. 9-B.

(Received in evidence and marked "Defendant's Exhibits Nos. 9, 9-A and 9-B" respectively.)

#### *Cross Examination*

By Mr. Davis:

XQ114 Mr. Friis, look at page 106 of the notebook, will you please. The arrangement represented in the diagram on that page is according to the scheme No. 2, that is, it is an arrangement in which the gain control is achieved by acting on the heterodyne oscillator amplifier, and not on the signal amplifier tube; is that correct?

A That is correct.



XQ115 Now, will you look at page 121 and the text, which reads as follows:

"As long as the input voltage to tube B is below V volts, the output plate current is zero, and the total amplification of the set maximum. As soon as the voltage increases (it is really the peak voltage) over V, the plate current will change the major grid voltage of the high frequency amplifier, and the amplification will drop. With V 22½ volts, the output was practically constant, for instance, the loop had no appreciable directional characteristic."

The V battery there referred to is shown on the diagram in the grid circuit of the B or detector tube, with a plus sign at the bottom, and a minus sign at the top; is that right?

A That is right.

XQ116 When you speak of that voltage being 22½ volts in the text, I understand that that was adjustable, and you used different voltages?

A You could change it down from 22½.

XQ117 And in the set which is here as Defendant's Exhibit 9-B, it was 4½ volts, is that it?

A And changeable to 22½.

XQ118 Well, what is the significance of the fact that the tag in the set Exhibit 9-B, which is attached to the lead to that battery is marked "4½"?

A Yes.

XQ119 He says, reading from the tag, the witness says "grid plus C battery"?

A "22½ volts battery in series adjustable."

XQ120 Then adjusted to minus 4½?

A Yes.

XQ121 I take that to mean that you did adjust it to minus  $4\frac{1}{2}$  when you used it; is that right?

A Well, when we used it to take the curve of the automatic gain control of the set shown in the memorandum dated April 14, 1924,—

XQ122 (interrupting): That is Figure 4 on that memorandum; is that right?

A That is Figure 4 on that memorandum,—I believe that that voltage was of the order of  $22\frac{1}{2}$  volts, and not  $4\frac{1}{2}$  volts.

XQ123 Well, that was my understanding too, from what you said before; but what is the significance of the memorandum on the tag on Defendant's Exhibit 9-B, which says: "Adjusted to minus  $4\frac{1}{2}$  volts"?

A I take that as indicating that you can change the different values. The batteries that were used at that time had clips coming out so that you could take off different voltages, and we evidently could use anything between  $22\frac{1}{2}$  volts and  $4\frac{1}{2}$  volts.

XQ124 Don't you think the memorandum on the tag indicates that when the set was actually in use, you did, as a matter of fact, adjust it to  $4\frac{1}{2}$  volts?

A I would not believe so, Mr. Davis. I would think when we used it in certain listening tests— $4\frac{1}{2}$  and in others we probably used  $22\frac{1}{2}$ .

XQ125 Who put this memorandum on those tags?

A All I can say is that I did not put the memoranda on.

XQ126 As I understand it, Mr. Friis, there was a 90 volt battery when the set was in use, which was put in this little box on the upper righthand corner of the top panel of the set?

A To my recollection, that is correct.

XQ127 And what kind of a battery did you use, do you remember?



A A dry battery.

XQ128 That is not a storage battery, but a dry battery?

A Yes.

XQ129 The tag attached to the lead from that battery is marked "minus 90 volts". That indicates, does it not, that whoever put that tag on there, intended to indicate that the minus terminal of the 90 volt battery was connected to this lead?

A That is correct.

XQ130 Then the tag here going to the plate, I take it, of the detector tube marked "plus 90 volts", that means that the other terminal of that 90 volt battery was connected to the plate of the detector tube?

A This is the detector tube (indicating).

XQ131 Then the tag we first referred to, marked "Grid plus C battery", is connected to what? The filament, I suppose, of the detector tube.

A That is the C battery.

XQ132 And this plus terminal then has the tag "grid plus C" went to the filament?

A That went to the filament, yes, it does.

XQ133 That is, in the set it does?

A Yes.

XQ134 This other tag which is marked "-C, 4½ volts," that is connected to the grid of the detector tube, is not that right?

A Yes, through a transformer.

XQ135 And that is the way it is in the set?

A That is the way it is in the set.

XQ136 So that both of those tags indicate that the voltage applied to the grid of the detector tube, at least when the tags were put on there, was 4½ volts, do they not?



A  $4\frac{1}{2}$  or  $22\frac{1}{2}$ .

XQ137 I do not want to make too much of a point of it, Mr. Friis, but there is nothing on the tags to indicate that the voltage actually applied to the grid was anything but  $4\frac{1}{2}$  volts?

A It does specify on the tag that we used  $22\frac{1}{2}$  volt batteries on that job.

XQ138 In series?

A I believe that we actually used either  $22\frac{1}{2}$  and sometimes we used  $4\frac{1}{2}$ .

XQ139 Will you look at Figure 2 of the memorandum of April 14, 1924, and the 90-volt battery about which we have been talking, and which was located in the little box in the upper righthand corner of the panel is shown in Figure 2 of the memorandum of April 14, 1924, near the lower lefthand corner of the diagram marked "90 volts," is that right?

A That is correct.

XQ140 And the other battery, that is the grid biasing battery—it was a separate battery?

A That is correct.

XQ141 Is marked E<sub>1</sub>c about the middle of that diagram?

A That is correct.

XQ142 In operation the current which flows through the resistance R of 20,000 ohms is the current from that 90-volt battery, is it not?

A That is the battery that supplies the current.

XQ143 If we trace the circuit there it starts at the plate or I will start at the plate of the tube, go over to the left to the battery, through the battery of 90 volts, down through the resistance R of 20,000 ohms, over to the left and then up to one terminal of the condenser C and then over to the right to the filament of the ampli-

fier tube and from the filament back down to the filament of the detector tube?

A That is correct.

XQ144 And the amount of current released from that 90-volt battery in the detector tube plate circuit which I have just traced depended upon the potential upon the control grid of the detector tube.

A That is correct.

XQ145 This is a parenthetical question, Mr. Friis, but I am just reminded of it as I look at this transformer 83-A. As I heard your testimony, I think you may have called it an amplifier. At any rate, it is a transformer and not an amplifier, is that right?

A That is right.

XQ146 Then we will correct the record if I am correct in thinking that you misnamed it. The value of this resistance R is given as 20,000 ohms. How does that compare with the internal resistance of the rectifier tube itself?

A That rectifier tube itself had, when used as an alternating current amplifier, an internal resistance very close to 20,000 ohms, the same value. It may be slightly more, 30,000 ohms, but it is of that general order.

XQ147 So that the arrangement was not such that the resistance gave to the circuit a rectilinear characteristic?

A Not quite.

XQ148 The tube actually operated with an exponential characteristic?

A Partly.

XQ149 It operated on the square law characteristic?

A It is a little difficult to talk about whether a circuit like this operated as a linear or as an exponential or a square law circuit. It is really nothing of the kind.

XQ150 I am going to ask you to explain that, but before you do so, I want you to say whether in your answer as to the internal resistance of the tube itself you were speaking of the internal resistance of the tube as it was actually used in this set?

A No. I specified that that is internal resistance of that type of tube as it is only used as a triode in an amplifier.

XQ151 What would be the internal resistance of this tube, the rectifier tube, as you actually used it in this set?

A As actually used in this set with the grid voltage  $E^1c$  —  $22\frac{1}{2}$  volts, and no signal coming in, the internal impedance of that tube would be infinite.

XQ152 And then as the signal came in and increased in strength until it overcame the negative biasing effect of the battery  $E^1c$ , whatever that value might be, tell us what would happen then?

A Then that internal impedance came down.

XQ153 So that by the time the thing began to act as automatic volume control the impedance of that tube had been reduced by the removal of the negative bias of the grid?

A That is correct.

XQ154 And then what was its value?

A I think it is extremely difficult to specify values.

XQ155 Can you give us the order of magnitude?

A No, I cannot. That circuit is so complicated that you cannot talk about impedance value in a case like this.

XQ156 Can you say this, that it was certainly in excess of 20,000 ohms?

A In a circuit like this, Mr. Davis, I believe the way to look at that is to take instantaneous values of voltage on the grid and then look at instantaneous values of the plate impedance about which you ask me. The



voltage on the grid is for a long time of the period negative and the tube is completely blocked during all that time. You have, you might say, an infinite impedance in the plate. Through a small section of the cycle, the grid is positive and at that time the plate impedance has dropped way down, it has dropped down to a value of 20,000 ohms.

XQ157 The word "impedance" means the same thing as "resistance" in this particular conversation this morning?

A Yes.

XQ158 What was the Mu or amplification constant of the A.V.C. triode that you actually used in this set?

A As I recall it, the Mu of that particular type of tubes we called the V tubes, was approximately 30 times.

XQ159 That would be regarded as a high Mu?

A It would.

XQ160 And the tube had correspondingly high internal resistance?

A High internal impedance, yes.

XQ161 In your direct examination you said that with the set, this Exhibit 9-B, as you operated it, it would be an improvement to have a more selective circuit between the amplifier circuits and the automatic volume control circuits. I take it that you meant that it would be of advantage in that set to do that because in that way you would separate the carrier from the modulation?

A It would, that is right.

XQ162 And in that set, as you were using it, supplying the entire signal to a triode detector, the disadvantage or imperfection that you have in mind, was that the modulation would affect the automatic volume control?

A That is correct.

XQ163 And that would result in distortion of conversation, the telephone speech?

A Although I might add, Mr. Davis, that we used circuits like that for more than a year, and we did not notice distortion. It is the amount of distortion—it is there, but it is slight.

XQ164 The actual use of this set, Mr. Friis, for ship-to-shore work, was some special use in this sense, was it not, that after all, when you were going to initiate a conversation with a ship, the operators at the station did the tuning of the set and got the circuit all set up and cleared before they turned it over to the speaker; that is, the client of the company, to use for telephone conversation; is that right?

A That is correct.

XQ165 And when in your patent you say on page 1, beginning line 58:

“It is therefore unnecessary to provide a special pilot wave as the carrier wave, when separated from the side waves is satisfactory for the purpose”.

You meant that when the carrier wave was separated from the voice modulations it was satisfactory for the purpose, is that right?

A I did.

XQ166 Now, in your patent, Mr. Friis, you referred to the patents to Espenschied and Bown, No. 1,447,773, and the patent to Affel, No. 1,468,687. Were you familiar when you built this Elberon set with the work that had been done by Espenschied and Bown and Affel in connection with automatic volume control?

A I was not.

XQ167 That reference was inserted by the Patent Department, I take it?

A That is correct.



XQ168 However, when on page 1, line 58 and following, you used the expression in the patent:

"It is therefore unnecessary to provide a special pilot wave."

The reference was back to the Affel patent, was it not, which had used a special pilot wave?

A That is correct.

XQ169 May we have that question corrected, and I think the answer will be the same; if not, say so, Mr. Friis. I should have referred not to Affel, but to the Espenschied and Bown patent as the one that has the special pilot wave?

A Yes.

XQ170 Otherwise your answer would be the same?

A Yes.

The Court: Shall we pause here?

Mr. Davis: Yes, sir.

The Court: The Court will recess for five minutes.

(After a short recess.)

XQ171 The remark you made before the recess with respect to linearity, not meaning anything, or something to that effect, those remarks had to do with your particular set and were not to be taken as general expression of opinion, were they?

A It has to do with the particular circuit involved. We were discussing that sort of thing.

XQ172 And you would agree with me, I think, that that circuit was one which did not give a linear response?

A I would.

XQ173 Now, will you look at Figure 3 of the memorandum of April 14th, 1924. As I understand it, the numerals 4, 8, 12, 16 and 20 going off to the left from



the zero point, represent negative voltage, do they not?

A Yes, on the grid.

XQ174 To what?

A Of the detector tube.

XQ175 And the line under "minus 16" indicates that 16 volts negative was applied to the grid of the detector tube?

A As a biasing voltage, yes.

XQ176 Now, the wave lines beneath that indicate what; that is, the lines marked "A.C. Voltage on grid of Rectifier Tube," what do they mean?

A That indicates a carrier voltage applied to the grid.

XQ177 And it indicates that the carrier voltage had been so far amplified that it had, as applied to the grid of the detector, the voltages indicated from this curve?

A That is right.

XQ178 So that in your set, you had amplified the carrier voltage before it got to the detector tube, up to a value of around 16 volts?

A That is correct.

XQ179 As I understand it, Mr. Friis, this Elberon receiver was not used, except experimentally?

A That is correct.

XQ180 And that was because of what reason?

A Because that particular ship-to-shore project was dropped during 1924.

XQ181 And, as I understand it, from testimony that has been put in the case by Mr. Betts and Mr. Scarr, and others, this system of automatic volume control, which you had worked out, and which is described in your patent, was applied by those gentlemen to the broadcast radio receiver, beginning sometime the latter part of the year 1925; is that right?

A I believe it is right, but I do not recall the details though.

XQ182 Well, you do not recall the date, but did you know that that group—tell me what group it was and what you do know about it?

A The Mr. Betts you mentioned, belonged to the Development Department, while we were in the Research Department, so the general way of working those projects was that we started in certain research work, and came to a certain stage, and they took it over and completed it, that is, developed it for practical purposes; and we had at that time, just like now, quite a good cooperation between the two departments, that is, I visited those people once in a while, and they came down and visited us in our field laboratories once in a while. That was the general idea of the connection between the two groups.

The Court: How close are you to the development work; in the same building?

The Witness: No. We are in the country. They are located in New York City, and we are in the country, about one hour's trip on the train.

XQ183 In that development, they had developed an arrangement by which you do away with the extra batteries that your set called for, including the 90-volt battery and the 22½ volt battery that we have been speaking about, had they not?

A Well, I do not recall; but it would be their job to do things like that.

XQ184 Do you know anything about the automatic volume control telephone speech receiver that was installed on the Leviathan by the Western Electric Company, or the Bell Laboratories?

A I do not believe I do.

XQ185 Were any variable Mu tubes used in that Elberon set?

A Not as we understand the term, variable Mu tubes, nowadays.

XQ186 And no screen grid tubes?

A No screen grid tubes.



XQ187 I understand that during the recess you looked with Mr. Wheeler at one of the tubes in the set which is marked as having an impedance of 50,000 ohms minimum, is that right?

A That is right.

XQ188 And in view of that your testimony would be that that 50,000 ohms is about the minimum impedance or resistance of the detector tube when it is acting for automatic volume control, is that right?

A No. My testimony, if I recall it right, is that the V type tube had approximately 30,000 ohms impedance, when it was used as an alternating current amplifier—

XQ189 30,000?

A That is what I said in my testimony. Reading on this tube now 50,000, that indicates that that was kind of low. Probably I believe the tubes ranged between 30 and 50. Some tubes will be higher and some will be lower.

Mr. Davis: That is all.

*Re-Direct Examination*

By Mr. Philbin:

RDQ190 Referring to these pages of your notebook and the memoranda, is the handwriting on the pages of your notebook your handwriting?

A It is.

RDQ191 And was it put there on or about the dates indicated?

A It was.

RDQ192 And did you make the circuit diagrams shown in these memoranda and notebook entries?

A We were just talking about page 106?

RDQ193 Yes, page 106.

A All the notebook entries I made. All the circuits in the notebook entries I made.

RDQ194 And on or about the dates as shown in the notebook?



A And on or about the dates shown in the notebook. We made memoranda, too.

RDQ195 I notice on some of these pages there is the name H. E. Overacker and on another page there is the name A. G. Jensen. Who were they?

A They were engineers that worked with me at Cliffwood at that time.

RDQ196 Also in the employ of the Western Electric Company?

A Also in the employ of the Western Electric.

RDQ197 You were asked about exponential and square law effects in the operation of this automatic gain control system and you said, as I understood you, that you did not have a linear effect. Will you tell us what as a practical matter linear effect and the exponential effect had to do with the final result of operation? If you had had a square law effect instead of a linear effect, what difference would it have made in the final result?

A In the final result of the automatic gain control circuit?

RDQ198 Yes.

A If we had used in our particular circuit what you might call a linear circuit, then our automatic gain control would not have been as stiff as it is with the circuit we used.

RDQ199 What difference would it have made to the listener if the automatic volume control had not been so stiff? What has stiffness got to do with the operation?

A Stiffness is an indication that the output level is more constant.

RDQ200 That is, that the result is more uniform?

A More uniform.

RDQ201 And so you employed a square law relation instead of a linear relation to get a more uniform result at the output?

A I would not say, Mr. Philbin, that we employed a square law relation. We employed some kind of exponential relation and that increased the uniformity of the output level.

RDQ202 What makes the difference in a circuit of yours as to whether it is square law or linear, that is, what parts, the condensers or resistance or tubes or what?

A That is the relationship between the resistance value and the impedance value of the tube.

RDQ203 That is, between the resistance on the outside of the tube and the resistance or impedance on the inside of the tube?

A That is correct.

RDQ204 You were asked about the Mu of the tubes that you employed. Will you tell us about what was the voltage amplification of those tubes as used in your set?

A The voltage amplification of the stages as we used them in that set was approximately 10 times.

RDQ205 Do you know about what is the voltage amplification of tubes used today in similar sets?

A Say 40 times.

RDQ206 You were asked about Affel. Did you know of any work by Affel with respect to automatic gain control when you commenced your work on automatic gain control?

A I did not.

Mr. Philbin: That is all.

*Re-Cross-Examination*

By Mr. Davis:

RXQ207 Mr. Friis, on the memorandum of April 14, 1924, in the upper righthand corner under date of April 15, 1924, is a list of names indicating that copies had been



sent to those persons on that date, is that right?

A That is correct.

RXQ208 Who is Mr. Bown to whom a copy was sent?

A That is Mr. Ralph Bown.

RXQ209 And he is the joint inventor in the Espen-schied and Bown patent?

A Yes.

RXQ210 And who is Mr. Clement, the last man on the list?

A He is the man employed by the RCA-Victor Com-pany now.

RXQ211 Do you know his full name?

A I believe Lewis M. Clement. At that time he was in the Bell System.

Mr. Davis: That is all.

(Witness excused.)

Mr. Philbin: It is stipulated that if H. E. Over-acker and Axel G. Jensen were called, they would respectively testify that they wrote their names on certain pages of the Defendant's Exhibits 9 and 9-A as of the dates shown thereby.

One of these names appears on page 121 of the notebook, there being on that page the words "Witnessed Horace E. Overacker." There is no date appearing by the side of the name "Horace E. Overacker." I understand that Mr. Friis would testify that that was put on on or about the date of February 28, 1924.

The Court: And that the matter therein con-tained was there when they signed.

Mr. Friis: Yes.

Mr. Philbin: Yes. The next page contains "Wit-nessed May 20, 1924, Axel G. Jensen." The next is the memorandum dated April 14, 1924, which



bears at the bottom the names H. T. Friis and H. E. Overacker.

Mr. Adams: It is not signed.

Mr. Philbin: This is typewritten.

Mr. Philbin: Defendants would wish to put on the record a stipulation that with respect to the Friis April 14, 1924 memorandum, Defendant's Exhibit 9-A, if L. M. Clement and Ralph Bown were called as witnesses in this suit, each would testify that he received a copy of such memorandum in April, 1924.

## PLAINTIFF'S EXHIBIT 28

## STIPULATION

It Is Hereby Stipulated by and between counsel for the parties hereto that the testimony hereto annexed (and photostatic copies of certain of the exhibits offered in connection therewith as set forth below) which was taken by deposition by the RCA Victor Company, Inc., in the case of RCA Victor Company, Inc., vs. Hazeltine Corporation, Equity No. 1071, in the United States District Court, District of Delaware, and received in evidence in that case, may be offered by either party in this case with the same force and effect as though the depositions were taken in this case, subject only to such objections as might be made if the depositions had been taken in this case. The testimony hereto annexed and covered by this stipulation is that of the following witnesses:

Philander H. Betts  
 Herbert B. Fischer  
 Edward Losey Nelson  
 Henry F. Scarr  
 Benny O. Browne (stipulated)

The annexed photostatic copies of exhibits (the originals of which were offered in connection with said testimony) covered by this stipulation are as follows:

## Plaintiff's Deposition Exhibit 1-A

"	"	"	1-B
"	"	"	2
"	"	"	3-A
"	"	"	3-B
"	"	"	3-C
"	"	"	4-A
"	"	"	4-B
"	"	"	4B-1
"	"	"	4-C

"	"	"	4C-1
"	"	"	4-D
"	"	"	4-E
"	"	"	4E-A
"	"	"	5
"	"	"	5-1
"	"	"	6-A
"	"	"	6-B
"	"	"	6B-A
"	"	"	7
"	"	"	7-A
"	"	"	8-A
"	"	"	8-B
"	"	"	8-C
"	"	"	9-A to 9-F inc.
"	"	"	10
"	"	"	12
"	"	"	13
"	"	"	14
"	"	"	15
"	"	"	16
"	"	"	17
"	"	"	18 (Note book pages 31, 32, 36, 48, 50, 51, 54, 70, 84, 86, 87, 104, 126.)

Pennie, Davis, Marvin & Edmonds.  
by R. M. Adams,  
Counsel for Plaintiff.

Darby & Darby,  
Floyd H. Crews,  
Counsel for Defendant.

Dated: Oct. 19, 1939.

The Exhibits referred to in this stipulation are reproduced in this record at pages 1404 - 1461.



UNITED STATES DISTRICT COURT,  
DISTRICT OF DELAWARE

RCA VICTOR COMPANY, INC.,  
*Plaintiff,*  
vs.  
HAZELTINE CORPORATION,  
*Defendant.*

EQUITY 1071.

New York, January 8, 1935.

Deposition of Philander H. Betts, a witness on behalf of the plaintiff, produced, sworn and examined pursuant to due notice on Tuesday, January 8, 1935, at 10 o'clock in the forenoon, and thereafter by adjournment as noted herein, at the offices of Messrs. Fish, Richardson & Neave, 20 Exchange Place, New York City, before James W. Maxwell, a notary public within and for the State of New York, County of Kings (with certificate filed and authorized to act in New York County), in a certain cause now pending in the United States District Court for the District of Delaware, between RCA-Victor Company, Inc., Plaintiff, and Hazeltine Corporation, Defendant.

Appearances:

Stephen H. Philbin, Esq., and  
William J. Barnes, Esq.,

Appearing as counsel for the Plaintiff;

William H. Davis, Esq., and  
Baldwin Guild, Esq.,

Appearing as counsel for the Defendant.

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PHILANDER H. BETTS, having been first duly sworn, in answer to interrogatories, deposes and says as follows:

*Direct examination by Mr. Philbin:*

Q. 1. Please state your name, residence and occupation.

A. Philander H. Betts, 209 South Lincoln Avenue, Elberon, New Jersey. I am a member of the technical staff of Bell Telephone Laboratories, Inc., 463 West Street.

Q. 2. What is the connection, if any, of Bell Telephone Laboratories, Inc., with the American Telephone & Telegraph Company or the Western Electric Company? A. Bell Telephone Laboratories, Inc. is the design and development organization preparing manufacturing information for the Western Electric Company and doing development and research work for the American Telephone & Telegraph Company.

Q. 3. What is the relation of the Western Electric Company to the American Telephone & Telegraph Company? A. The Western Electric Company is the manufacturing organization for the Bell System, of which the American Telephone & Telegraph Company is the managing head.

Q. 4. How long have you been connected with the Bell Telephone Laboratories, Inc., or the Western Electric Company? A. Since September, 1922.

Q. 5. What technical education have you had? A. B. S. and E. E. at Rutgers College. I graduated in 1922. Prior to that time I was a licensed commercial radio operator.

Q. 6. What work were you doing in the latter part of 1925? A. As a member of the radio apparatus development department, I was one of the group engaged in the development and design of a superheterodyne radio receiver for operation from A. C. source.

Q. 7. With what company were you then connected? A. Bell Telephone Laboratories, Inc.

Q. 8. About when did the development of this A. C. superheterodyne commence? A. The middle of 1925.

Q. 9. I show you a "Memorandum for File" bearing the date 9/14/25 and entitled: "Preliminary study of a double detection A. C.-operated radio receiver," bearing your name and also your initials P. H. B., and also a blueprint dated September 9, 1925, entitled: "Preliminary circuit for a double detection A. C.-operated radio receiver," bearing your initials, as "drawn" and as "engineer," P. H. B., No. ES-403489, and ask you if you can identify those. A. This is a memorandum prepared by myself to outline the aims in connection with the development of a double detection A. C.-operated radio receiver. Preparation was begun early in September, and the memorandum in question was typed on 9/14/25, was initialed by myself, as shown by my initials, and was forwarded to my supervisor, who added his initials, S. E. A., for S. E. Anderson, who forwarded it to his supervisor, who also placed his initials thereon, E. L. N., for E. L. Nelson. The tentative circuit diagram is referred to in this memorandum by its number ES-403489.

The accompanying blueprint is a copy of that tracing, prepared by me on September 9, 1925, as shown by the date thereon and my initials both after the titles "drawn" and "engineer". This circuit diagram shows 12 vacuum tubes.

Mr. Philbin: The plaintiff offers in evidence the memorandum as Plaintiff's Exhibit 1-A and the circuit diagram as Plaintiff's Exhibit 1-B.



The papers were marked, respectively, Plaintiff's Exhibit 1-A and 1-B for Identification, January 8, 1935.

Q. 10. How many tubes are shown in the circuit diagram for this superheterodyne receiver? A. This circuit diagram shows twelve tubes, two of which function as a power rectifier and two as a power amplifier. These four tubes were of the 205-D type. The remaining eight tubes were of the 231-D type or 230-D type, and their function, reading from left to right, in the first row of tubes at the top of the diagram, is: Radio frequency amplifier, local oscillator, first detector, first and second intermediate frequency amplifiers. From left to right in the second row of tubes: Third radio frequency amplifier, second detector, and the first stage of audio frequency amplification.

Q. 11. What do you understand by "automatic volume control"? A. Automatic volume control is a self-actuating device for maintaining the output substantially constant over a wide range of variable input.

Q. 12. Is there any automatic control referred to in this memorandum or shown in this circuit diagram? A. No.

Q. 13. I now show you a circuit diagram bearing the words "Drawn Dec. 30, 1925, by H. B. Fischer; witnessed and understood, P. H. Betts, 1/13/26; Harry F. Scarr, 1/13/26," and ask you if you can identify that. A. This is a circuit diagram of a double detection A. C.-operated radio receiver, which was drawn by Mr. H. B. Fischer, and witnessed by myself on January 13, 1926.

Q. 14. What do you mean by "double detection receiver?" A. A double detection receiver is otherwise known as a superheterodyne receiver.

Q. 15. Who was Mr. H. B. Fischer? A. Mr. H. B.

Fischer was one of my associates in the group which had this receiver under development.

Q. 16. Who was Mr. Henry F. Scarr? A. He was also a member of the same group.

Q. 17. Were they engineers or technical people? A. They were engineers.

Q. 18. Did this receiver contain tubes which functioned the same as in the September 14, 1925, circuit? A. Yes, it had tubes which functioned the same as in the September 9th drawing, but it had also two additional tubes which functioned for the tuning indication and automatic volume control.

Q. 19. Will you point out the automatic volume control tube or tubes? A. The two tubes used for the automatic volume control are designated "4" and "C". You will find the numbers under the filaments of the tubes. They are in the lower portion in the center of the diagram.

Q. 20. What fed those tubes; that is, where did they derive the energy to perform their A. V. C. function? A. All of the D. C. potentials were derived from the one rectifier source, shown as a full wave rectifier in the lower right hand corner of the diagram. The A. C. for operation of the automatic volume control was taken off by a separate winding in the W-6415 transformer which is connected between the output of the third intermediate frequency amplifier and the input of the second detector. This winding was connected between the grid and filament of the A. V. C. amplifier designated "4". This amplifier tube was transformer-coupled to the control tube "C", which functioned essentially as a rectifier. The output of this tube controlled the grid bias of the first and second intermediate frequency amplifiers designated "1" and "2", thus functioning for the automatic volume control.

Q. 21. Was the A. V. C. rectifier tube fed from the

input or the output of the second detector tube? A. It was fed from the input of the second detector.

Q. 22. Can you identify the writings on this sketch as those of the respective men whose names are written on the sketch? A. Yes, their signatures are familiar to me.

Q. 23. And do you identify them? A. I identify them as such.

Mr. Philbin: The plaintiff offers in evidence the diagram of December 30, 1925, as Plaintiff's Exhibit 2.

Diagram was marked Plaintiff's Exhibit 2 for Identification, January 8, 1935.

Q. 24. I next show you a memorandum dated January 2, 1926, and containing two sheets, and another memorandum dated January 4, 1926, containing two sheets, both containing your name, and ask whether you can identify those memoranda. A. These are photostatic copies of memoranda written by me in long hand. The first, dated January 2, 1926, is entitled, "Suggestion for D. C. Amplifier". The second one, dated January 4, 1926, is entitled "Suggestion for Modified Automatic Gain Control to use one source of E. M. F. in place of A, B and C Batteries".

Q. 25. Did you write those memoranda on or about the dates stated therein? A. Yes.

Q. 26. The memorandum of January 2, 1926, at the end bears the names H. B. Fischer, Henry F. Scarr and S. E. Anderson. Do you recognize their signatures? A. Yes, I am familiar with their signatures and identify them as such.

Q. 27. Is Mr. Anderson alive now? A. No.

Q. 28. Are the other two alive? A. Yes.

Q. 29. Do you know whether or not those signatures were put on this memorandum on or about January 2, 1926? A. I believe they were affixed at the time of the



witnessing of the second memorandum on January 4th.

Q. 30. Referring to the second memorandum, it bears the names at the end of the same Mr. Scarr and Mr. Fischer, but not Mr. Anderson. Do you recognize the signatures of Mr. Scarr and Mr. Fischer on that January 4th memorandum also? A. Yes, their signatures follow the letter "W and U", signifying "Witnessed and understood".

Mr. Philbin: The plaintiff offers in evidence as Plaintiff's Exhibit 3-A the January 2, 1926, memorandum, and as Plaintiff's Exhibit 3-B, the January 4, 1926, memorandum.

The papers were marked, respectively, Plaintiff's Exhibits 3-A and 3-B for Identification, January 8, 1935.

Q. 31. I also show you another sheet dated "1/4/26," and bearing your name as well as that of Mr. Scarr and Mr. Fischer, and ask you whether you can identify it, this sheet commencing "The circuit shown in Fig. 3 of the description," and so forth. A. This is a photostatic copy of a memorandum written by me in long hand on January 4, 1926, and witnessed by Henry F. Scarr and H. B. Fischer, and refers to figure 3 in each of the memoranda of January 2nd and January 4th.

Q. 32. Do you recognize the signatures of Mr. Fischer and Mr. Scarr? A. Yes.

Mr. Philbin: The plaintiff offers in evidence this last memorandum as Plaintiff's Exhibit 3-C.

Paper was marked Plaintiff's Exhibit 3-C for Identification, January 8, 1935.

Q. 33. I note that on Plaintiff's Exhibit 3-B, the first January 4th memorandum, at the top the figure 4 appears to have been written over the numeral 3. Why was that?

A. It is my remembrance that January 3rd was a Sunday and that I began the preparation of that memorandum at that time, and brought it in to work with me the following Monday. Both Mr. Scarr and Mr. Fischer fell into the same error in dating their signatures on Plaintiff's Exhibit 3-B. On Plaintiff's Exhibit 3-C, Mr. Scarr has the correct date, but Mr. Fischer again made the same error in dating his signature "1/3" corrected to "1/4".

Q. 34. I also notice that on the same memorandum, Plaintiff's Exhibit 3-C, the numeral "6" in "1926" seems to be in stronger lines than the "192". A. I do not believe that has any particular significance, as the second page of the same memorandum has the "1926" clearly designated.

Q. 35. Well, can you give any explanation of why the figure "6" appears to be heavier than "192"? A. It might have been incorrectly shown as "1925" and corrected to "1926".

Q. 36. Do any of these memoranda, Plaintiff's Exhibits 3-A, 3-B and 3-C, describe an automatic volume control? A. Yes.

Q. 37. Which ones? A. Plaintiff's Exhibit 3-B.

Q. 38. Does the description of an automatic volume control in Plaintiff's Exhibit 3-B add anything to the automatic volume control arrangement shown in the circuit diagram of December 30, 1925? A. No.

Q. 39. I show you a circuit diagram entitled "Schematic Diagram of DDAC-1 Radio Receiver," bearing the words, "Drawn Jan. 13, 1926, by Henry F. Scarr; witnessed and understood, P. H. Betts, 1/13/26," and ask you if you can identify that drawing. A. This is a photostatic copy of a schematic diagram prepared and signed by Henry F. Scarr on January 13, 1926, showing slight modifications from the circuit of December 30, 1925, offered as Plaintiff's Exhibit 2.

Q. 40. Does the superheterodyne or double detection receiver shown in this January 13, 1926, diagram contain the same number of tubes, performing the same functions, as the December 30, 1925 diagram? A. Yes.

Q. 41. And that includes the automatic volume control tubes? A. Yes.

Q. 42. Do you recognize Mr. Scarr's signature and handwriting? A. I do.

Q. 43. And did you sign as indicated on or about January 13, 1926? A. Yes.

Mr. Philbin: The plaintiff offers in evidence this sketch as Plaintiff's Exhibit 4-A.

Paper was marked Plaintiff's Exhibit 4-A for Identification, January 8, 1935.

Q. 44. I now show you another diagram bearing the same title "Schematic diagram of DDAC-1 Radio Receiver," and the same words as the other diagram, Plaintiff's Exhibit 4-A, with the following additional words, "Key connections corrected Jan. 14, 1926, H. F. S. P. H. B". Can you identify that circuit diagram? A. This is a photostatic copy of the same drawing referred to as Plaintiff's Exhibit 3-A after the connections to the key were corrected on January 14, 1926, by myself, as shown by my initials. Mr. Scarr also initialed the drawing, to show that he had seen the drawing after it was changed.

Q. 45. Who wrote the words "Key connections corrected Jan. 14, 1926?" A. That is in my handwriting.

Q. 46. Did you write those words and sign your name as of the date indicated? A. Yes.

Mr. Philbin: The plaintiff offers this diagram as Plaintiff's Exhibit 4-B.

Paper was marked Plaintiff's Exhibit 4-B for Identification, January 8, 1935.

Q. 47. I note on this diagram that there are some col-



ored lines. What does that mean? A. This is a photostatic copy on which one of the engineers of our group traced out parts of the circuit. The red lines in this particular case follow the filament circuit. Certain other notations have been made on this photostat in pencil, such as "min and max" with respect to the potentiometer, which has the designation "gain" and the word "output" is also in pencil in connection with the potentiometer to the left, which has "min and max". Certain other changes have been noted in ink, showing the addition of certain resistances and the addition of numerical constants for certain resistances, and the designation of the vacuum tubes in accordance with their function.

Q. 48. Is the fundamental circuit the same as in the December 30, 1925, and January 13, 1926, diagrams, including the use of automatic volume control? A. Yes, the same number of tubes are employed having the same circuit functions.

Q. 49. Do you know who colored the lines on Plaintiff's Exhibit 4-B and made these other notations that you spoke of? A. No. It was one of the engineers of the group, but which one I cannot say for sure.

Q. 50. Was a receiver built in accordance with the December 30, 1925, diagram? A. It was.

Q. 51. About when? A. Just prior to the preparation of this drawing, which was prepared to show the constants actually used.

Q. 52. Was it operated at or about that time? A. Yes.

Q. 53. Was a receiver built in accordance with the January 13, 1926, diagram? A. Not as a separate receiver. The original one was modified in accordance with that diagram.

Q. 54. When was this modified January 13, 1926, receiver built, about? A. The latter part of December.

Q. 55. Was it operated? A. Yes.

Q. 56. When? A. Well, work was more or less con-

tinuous on this receiver from the time it was constructed on through until the time development work on the receiver was completed late in 1926.

Q. 57. I next show you a paper entitled, "Potential diagram per Jan. 13, 1926, schematic diagram of DDAC-1 radio receiver," bearing your initials P. H. B. and dated 1/14/26, and ask you whether you can identify that.

A. This is a photostatic copy of a diagram prepared by myself, as shown by my initials, on the date 1/14/26, to accompany the complete schematic diagram of January 13, 1926, corrected as of January 14, 1926, to show the values of voltage, current and resistance involved in the D. C. portion of the circuit.

Mr. Philbin: The plaintiff offers this diagram as Plaintiff's Exhibit 4-C.

The paper was marked Plaintiff's Exhibit 4-C for Identification, January 8, 1935.

Q. 58. I observe in this potential diagram various values for volts and for current in the units of milliamps, and for resistance in the units of ohms. Did you write those values? A. Yes, it was my part of this job to calculate the constants for the circuit and keep this part of the information up to date. I might add that the left hand column entitled "Unit" identifies the particular piece of apparatus or portion of the circuit to which the measurement or calculation applies.

Q. 59. Does the circuit diagram show an automatic volume control connection? A. It does. The automatic volume control tube is designated "C", and under the column marked "unit" it is labeled "control". The associated amplifier designated "4" is marked "Auto gain I. F. Amp. 4". The words "auto gain" refer to the resistance values of the potentiometer used in the automatic volume control.

Q. 60. What did "auto" mean? A. That was an abbreviation for "automatic".

Q. 61. So "automatic gain control" means "automatic volume control", as you used it? A. Yes.

Q. 62. Is the automatic volume control in this potential diagram the same as that shown in the January 13, 1926, circuit diagram? A. Yes.

Q. 63. Are values given in this potential diagram for the automatic gain control potentials? A. Only as to filament current and plate currents for the tubes involved.

Q. 64. What tubes are those? A. The "I. F. Amp. 4" and the control tube.

Q. 65. What do you mean by the control tube? A. The tube which we have considered as the automatic volume control device.

Q. 66. That is, the rectifier? A. That is right.

Q. 67. I next show you a paper entitled "Schematic diagram for DDAC-1 radio receiver circuit revision of Feb. 26, 1926", and also bearing the following: "P. H. Betts, March 2, 1926; witnessed and understood by H. B. Fischer, 3/2/26; S. E. Anderson, 3/2/26; H. F. Scarr, 3/2/26." Do you recognize that diagram? A. This is a photostatic copy of a schematic diagram drawn by me on March 2, 1926, to show the revisions made in Mr. Scarr's diagram of February 13th, with all corrections made up until February 26th. The drawing was completely new at this time, rather than a revision of Mr. Scarr's original diagram. As indicated by their signatures and the accompanying dates, the drawing was witnessed and understood by Mr. H. B. Fischer, Mr. S. E. Anderson and Mr. H. F. Scarr.

Q. 68. Do you recognize their signatures? A. Yes. This photostatic copy, in addition, bears tracings in black pencil and in yellow pencil, probably made by Mr. B. O. Browne, whose initials also appear on the drawing, to assist him in tracing out the circuit.



Mr. Guild: I object to this witness testifying concerning the presumed understanding of others.

Q. 69: Who was Mr. B. O. Browne and what were his duties at that time? A. Mr. B. O. Browne was a mechanical designer who was assigned to the job of paralleling our electric research in connection with this circuit with the necessary mechanical design which would result in a physical receiver suitable for commercial sale.

Q. 70. Do you know whether or not Mr. Scarr, Mr. Fischer and Mr. Anderson understood the operation of these various receivers and modifications thereof during 1925 and 1926? A. Yes.

Q. 71. You stated that Messrs. Fischer, Anderson and Scarr understood the operation of the DDAC-1 radio receiver as of March 2, 1926. What was the basis of that statement? A. This diagram bears the statement "Witnessed and understood by," followed by the signatures of the three engineers in question.

Mr. Guild: I repeat my previous objection, in view of the witness' explanation.

Mr. Philbin: The plaintiff offers the diagram in evidence as Plaintiff's Exhibit 4-D.

The paper was marked Plaintiff's Exhibit 4-D for Identification, January 8, 1935.

Q. 72. Did you discuss this receiver with Messrs. Anderson, Scarr and Fischer on March 2, 1926, or about that time? A. Undoubtedly, inasmuch as all of us were working on the same job.

Q. 73. What were they doing on this receiver? A. Mr. Scarr was making most of the laboratory measurements; Mr. Fischer was assisting with the physical work of modification of the circuits and building the apparatus, and Mr. S. E. Anderson was the supervisor in charge

of the work, to whom Mr. Scarr, Mr. Fischer and myself reported.

Q. 74. I next call your attention to another paper entitled, again, "Schematic Diagram of DDAC-1 Radio Receiver, circuit revision of Feb. 26, 1926," bearing the same names as "Drawn" and as "witnessed and understood by" as the previous one and, in addition, in the upper left hand corner, the following: "Change 1: Filament sequence R and O interchanged to reduce filament coupling, March, 1926, P. H. B. 2: Ground removed to positive end of filament string March 19, 1926, P. H. B." and ask you whether you can identify that diagram? A. This is a photostatic copy of a later revision of the schematic diagram originally prepared on March 2nd, but corrected as of the changes made up to and including March 19, 1926, as shown by my initials following that date.

Q. 75. Who wrote the words "Change 1: Filament sequence," and so forth? A. I did. They are printed, rather than written.

Q. 76. Did you write those words and put your initials on, on March 19, 1926? A. Yes.

Mr. Phäbin: The plaintiff offers this diagram as Plaintiff's Exhibit 4-E.

Paper marked Plaintiff's Exhibit 4-E for Identification, January 8, 1935.

Q. 77. I notice some colored lines on this drawing. Do you know who made those colored lines? A. No.

Q. 78. I show you a paper entitled: "Schematic Diagram of DDAC-2 Radio Receiver," bearing the words "drawn by P. H. Betts; issue 1: April 24, 1926; issue 2, May 2, 1926; issue 3, May 19, 1926." Can you identify it? A. This is a photostatic copy of a schematic diagram of the same radio receiver described or shown in

the schematic diagram of DDAC-1 of February, 1926, with the changes which were incorporated up to and including May 19, 1926. The diagram also shows certain changes in the physical line-up of apparatus, showing consideration from a physical standpoint, of progress in the design of the receiver.

Q. 79. Did you make that drawing? A. I did.

Q. 80. As of what date or on what date? A. I believe it was completed on April 24, 1926, as shown by the date opposite "Issue 1".

Mr. Philbin: The plaintiff offers this diagram as Plaintiff's Exhibit 5.

Paper was marked Plaintiff's Exhibit 5 for Identification, January 8, 1935.

Q. 81. I observe some pencil notations on this diagram. What do they mean? A. "See later issue, B. O. B."; also certain values have been modified in pencil from those shown on the original drawing.

Q. 82. Who was "B. O. B.?" A. Mr. B. O. Browne.

Q. 83. I show you a paper entitled "Schematic Diagram of DDAC-3 Radio Receiver," bearing the words "drawn by P. H. Betts; issue 1, 7/23/26." Can you identify that? A. This is a photostatic copy of a schematic diagram of a superheterodyne A. C. operated radio receiver, showing the modifications up to and including 7/23/26, at which time this drawing was completed by myself.

Mr. Philbin: The plaintiff offers this diagram as Plaintiff's Exhibit 6-A.

Paper was marked Plaintiff's Exhibit 6-A for Identification, January 8, 1935.

Q. 84. Do you know who colored the lines on this drawing? A. No.



Q. 85. I observe some words and numerals on the drawing. Do you know who made those? A. I do not know, but I believe they were added by Mr. B. O. Browne to indicate the circuit positions for the physical pieces of apparatus employed in the receiver which was at that time under construction.

Q. 86. I show you a paper entitled "Schematic Diagram of DDAC-3 Radio Receiver," bearing the words "drawn by P. H. Betts; issue 1, 7/23/26; issue 2, 10/28/26." Can you identify that? A. This is a photostatic copy of a schematic diagram of a superheterodyne A. C. operated radio receiver, showing the modifications up to and including 10/28/26, originally prepared 7/23/26.

Mr. Philbin: The plaintiff offers this in evidence as Plaintiff's Exhibit 6-B.

Paper was marked Plaintiff's Exhibit 6-B for Identification, January 8, 1935.

Q. 87. Do you know who colored the lines on this exhibit? A. No.

Q. 88. Do you know who put the words and figures on it which are not in the drawings themselves? A. No.

Q. 89. Referring to this diagram, as well as the earlier diagram of the DDAC-3 receiver, Plaintiff's Exhibit 6-A, who put on the numerals and the words which are contained in the drawings themselves, who made those? A. I did.

Q. 90. And when? A. At the time the drawing was originally prepared.

Q. 91. I show you a paper entitled, "Schematic Diagram DDAC-4 Radio Receiver," bearing your signature and the date 5/13/27. Can you identify that? A. This is a photostatic copy of a schematic diagram of a superheterodyne A. C. operated radio receiver, showing the modifications made up to and including 5/13/27.

Q. 92. When did you make this drawing? A. It was completed as of that date.

Q. 93. Did you put on the numbers and the words which are in that drawing? A. Yes.

Q. 94. Referring to the various parts and values? A. Yes.

Q. 95. When? A. As part of the original drawing.

Q. 96. I note the words at the top of the drawing, "B. O. Browne, room 193-B." Did you put those words on? A. No, that appears to be Mr. Browne's signature and his location.

Q. 97. What was room 193-B? A. That was the room in which Mr. Browne had his desk.

Q. 98. Where? A. At 463 West Street.

Q. 99. Was that the office of the Bell Telephone Laboratories at that time? A. Yes.

Mr. Philbin: I offer this diagram as Plaintiff's Exhibit 7.

Paper was marked Plaintiff's Exhibit 7 for Identification, January 8, 1935.

Mr. Guild: I want it understood that the defendant is reserving the right to object, and does object, to this and to any and all of the other similar exhibits offered here this morning, after the evidence is sufficiently developed to determine whether these are the best procurable copies.

Q. 100. I now show you three papers, each entitled "DDAC-5 schematic diagram for the 7-A radio receiver," each bearing in the upper left hand corner the date 7/12/27 and your name; the second having at the lower right hand corner "Issue 2, 7/15/27, P. H. B.," and the third being the same as the second, with the addition at the top of the words "B. O. Browne, room 193-B," the date and other words. Can you identify these three pa-

pers? A. These are photostatic copies of the schematic diagrams of the superheterodyne A. C. operated radio receiver in its essentially complete or semi-final form, originally prepared on 7/12/27 and modified slightly on 7/15/27, as shown in the second and third papers designated "Issue 2." The first photostat shows no changes except the addition of Mr. B. O. Browne's signature and his room number 193-B. The second paper shows the addition of certain apparatus and additional designations for apparatus not otherwise specified. The third is a reduced size copy of the issue 2 drawing dated 7/15/27, but showing only part of the changes which had been made in the larger copy.

Mr. Philbin: The plaintiff offers in evidence the three papers referred to as Plaintiff's Exhibits 8-A, 8-B and 8-C.

Papers were marked, respectively, Plaintiff's Exhibits 8-A, 8-B and 8-C for Identification, January 8, 1935.

Q. 101. Did you make these drawings on the dates indicated? A. I did.

Q. 102. I observe that in the drawings there are various values given and various words such as "Ant. tuning" and "Ant. Coup." Who wrote those words and those values? A. I did. They were part of the original drawing.

Q. 103. And were they made at the same time as the original drawing? A. Yes.

Q. 104. I now show you six photographs numbered from 27882 to 27887, inclusive, and ask you to tell us what they are. A. These are photographs of one of the 7-A radio receivers. The different views show the cabinet closed and open, front and back, a close-up of the tuning panel, as well as a top view showing the 231-D tubes in their compartment.



Mr. Philbin: The plaintiff offers in evidence the photographs referred to as Plaintiff's Exhibits 9-A to 9-F, inclusive.

Photographs were marked Plaintiff's Exhibits 9-A to 9-F for Identification, inclusive, January 8, 1935.

Q. 105. When were these photographs taken, approximately? A. I believe they were made soon after the completion of the physical sets in May, 1927.

Q. 106. How many 7-A receivers were built? A. Two.

Q. 107. What was done with these receivers? A. They were loaned out for trial to various executives of the company, and one of these is now in the home of Mrs. E. B. Craft, and the other is now in the office of the patent department of the Bell Telephone Laboratories on Hudson Street, New York City.

Q. 108. Did the Bell Telephone Laboratories, Inc., the Western Electric Company or the American Telephone & Telegraph Company ever go into the commercial manufacture of these receivers? A. No.

Q. 109. Now going back to these various receivers or modifications thereof, about when was the receiver shown in the December 30, 1925, diagram first operated? A. (No response.)

Q. 110. That is, was it before or after December 30, 1925? A. I believe it was operated shortly before this diagram was prepared.

Q. 111. Was the diagram prepared from the receiver? A. That is my recollection.

Q. 112. Did it operate satisfactorily? A. Yes.

Q. 113. Do you know whether or not each of the receivers or modifications shown in the circuit diagrams referred to, describing the DDAC-1, DDAC-2, DDAC-3, DDAC-4 and DDAC-5 receivers were constructed and operated? A. At least one additional experimental receiver.

er was built between the time of the December 30, 1925, set and the completion of the two 7-A radio receivers. This other set was modified from time to time, to bring it up to date in accordance with the changes which were indicated.

Q. 114. Was a set or were sets constructed in accordance with each of the circuit diagrams of the DDAC-1, 2, 3, 4 and 5, receivers? A. The sets, at some time during their existence, had the circuits identical with those shown in the diagrams for the DDAC-1, 2, 3, 4 and 5.

Q. 115. Were they operated in accordance with those diagrams? A. Yes.

Q. 116. Did each of the receivers operated in accordance with the December 30, 1925, diagram and the DDAC-1, 2, 3, 4 and 5, diagrams, have automatic volume control? A. Yes.

Q. 117. Do the drawings show that they had automatic volume control? A. Yes.

Q. 118. You have stated that the December 30, 1925, receiver, had automatic volume control, utilizing an amplifier tube and a rectifier tube and connected to the input of the second detector. Will you tell us whether that same arrangement was used in each of the succeeding receivers? A. At a later date the input to the A. V. C. amplifier was changed from the input to the second detector, to the output of the second detector. This was done as shown in the drawing dated April 24, 1926, and as shown in the DDAC-2 diagram offered as Plaintiff's Exhibit 5.

Q. 119. Was that same arrangement as shown in Plaintiff's Exhibit 5 employed in all of the succeeding receivers? A. Yes.

Q. 120. Why did you change the A. V. C. connection from the input to the second detector to the output of the second detector? A. The reason was two-fold. One

was to make use of the additional gain to be derived from the amplifying action of the detector; and the second was to reduce the effect on the intermediate frequency characteristic, inasmuch as we found a reaction back from the A. V. C. amplifier when connected across the input of the detector tube.

Q. 121. I show you a drawing entitled "A. V. C. System of DDAC and 7-A receivers." Will you tell us whether that correctly shows the A. V. C. system used in all the DDAC and 7-A receivers you have referred to, and also as shown in the circuit diagrams you have referred to, commencing with December 30, 1925, and later diagrams? A. Yes, this is a simplified schematic circuit, as far as the A. V. C. system is concerned, of all of those previous diagrams.

Mr. Philbin: The plaintiff offers the diagram in evidence as Plaintiff's Exhibit 10.

Paper was marked Plaintiff's Exhibit 10 for Identification, January 8, 1935.

Q. 122. Please describe briefly the operation of this system, without reference to the A. V. C. part of it. A. A typical superheterodyne circuit is indicated, beginning with the antenna circuit shown coupled to a wave frequency tube stage of amplification, followed by the first detector and the associated oscillator; then followed by three stages of intermediate frequency amplification, as indicated by the transformer L-1 and L-2 associated with the input of the first I. F., L-3 associated with the plate circuit of the same tube, coupled to L-4, associated with the grid circuit of the second I. F., L-5 associated with the plate circuit of that same tube, coupled to L-6, associated with the input of the third I. F. The output of the third I. F. is coupled by L-7 to the two windings indicated as L-8 and L-9. L-9 furnishes input to the



second detector, whose output is transformer-coupled through L-10 and L-11 to the first A. F. and thence to the second A. F. and, from there, to the loud speaker.

Q. 123. Does "A. F." mean audio frequency? A. Right.

Q. 124. And I think you said "I. F." is "intermediate frequency"? A. That is right.

Q. 125. Will you now describe the automatic volume control part of the system, as used in the December 30, 1925, and the DDAC-1 receivers, and also as modified and used in the other receivers. A. As originally indicated in the December 30, 1925, diagram and the DDAC-1 diagram, the input to the I. F. amplifier associated with the A. V. C. rectifier obtained its input from the coil designated L-8. This amplifier was transformer-coupled to the A. V. C. rectifier, whose plate circuit comprises a resistance, R-3, and a potential source derived by the voltage drop across the resistance R-2 connected between the plate, R-3, and the filament of the A. V. C. rectifier. The plate of the A. V. C. also has a D. C. connection to the grids of the first and second I. F. amplifier tubes. The grid bias for the A. V. C. rectifier is obtained by the potential drop through the resistance R-1. This tube is biased so that an increase in signal results in an increase in the direct current flowing in its plate circuit. An increase in that current increases the potential drop across the resistance R-3, which is a part of the rectifier plate circuit. Inasmuch as one end of the resistance R-3 is connected to the anodes of the first and second I. F. amplifiers and the other end of this resistance is connected, from a D. C. standpoint, to the grids of those tubes, an increase in the current through R-3 will increase the negative bias applied to the grids of the first and second I. F. amplifier tubes, thereby decreasing their gain. The net effect is that as an increase in signal reaches the second detector, the gain of the intermediate

frequency amplifiers ahead is reduced to maintain an output substantially constant when the input varies over a fairly wide range.

In the later circuits, beginning with the DDAC-2 diagram, the input to the I. F. amplifier associated with the A. V. C. rectifier was obtained from the plate of the second detector, as shown in a dotted line; and the connection to L-8 left open.

Q. 126. You used the word "anode." Does that mean the same thing as the plate? A. That is my error. I should have said "cathode."

Q. 127. Does "cathode" mean the same thing as "filament?" A. In this case, inasmuch as they were a filamentary type of tubes, yes.

Q. 128. I observe in the circuit of the first I. F. tube a resistance marked R-4 and a condenser marked C-1, and in the circuit of the second I. F. tube a resistance marked R-5 and a condenser marked C-2. What did those condensers and resistances do in the operation of the A. V. C. system? A. Inasmuch as the plate circuit of the A. V. C. rectifier contains some component of the intermediate frequency, it was necessary to prevent that frequency from reaching the grids of the first and second I. F. amplifier tubes, to avoid regeneration. These resistances and condensers functioned as filters in this respect, and also provided a suitable time constant for governing the rapidity with which the A. V. C. functioned.

Q. 130. What was the time constant in each of these tubes? A. In the values finally decided upon, R-4 and R-5 were 100,000 ohms, and C-1 and C-2 were each  $\frac{1}{2}$  microfarads, giving an approximate time constant of one twentieth of a second.

Q. 131. In the operation of the systems of these receivers, do the grids of the amplifier tubes, the first I. F.

and the second I. F., become increasingly negative with increase of signals? A. Yes.

Q. 132. Was the plate or anode of the A. V. C. rectifier negative or positive with respect to the cathodes of those amplifier tubes? A. The plate was negative with respect to the cathodes of those tubes, by virtue of the drop through the resistance R-3.

Q. 133. Did you test these receivers with respect to the effect of the A. V. C. operation? A. Yes, many times.

Q. 134. What difference, if any, was there occasioned by the use of A. V. C. in these receivers? A. Well, signals of widely varying intensity could be received with substantially constant volume from the loud speaker. It was particularly noted, in some of our observations, that programs which were distinctly unpleasant due to their varying intensity, could be enjoyed when the A. V. C. was functioning.

Q. 135. What happened when you took off or short-circuited the A. V. C. in these receivers? A. Well, if the A. V. C. were merely short-circuited, the gain of the receiver went up to the maximum value, and hence would be overloaded by almost any signal which would be received, due to the maximum gain of the receiver being extremely high. However, practically all models of these receivers were equipped with optional manual control of the gain, which could be employed when A. V. C. was not desired.

Q. 136. Where were these sets operated in 1925 and 1926? A. The initial operation of course was in the laboratories at West Street; but field trials were made at my home in Belmar, New Jersey, and also at Pocono Manor, near Mount Pocono, Pennsylvania. Just prior to the Pocono Manor demonstration, the set was at Mr. Anderson's home for several days in Maplewood, New Jersey.



Q. 137. When was the set used at Pocono Manor? A. Unless I use my diary, I cannot remember the exact date.

Q. 138. All right, use your diary. A. Well, by reference to my diary, the demonstration at Pocono Manor was on the night of April 13-14, 1926.

Q. 139. Apart from your diary, can you recall about when it was, by connection with any other facts? A. Well, the date can also be established by expense vouchers which were submitted to the payroll department or the accounting department of the laboratories.

Q. 140. Who else was present during the operation of this set at Pocono Manor? A. Mr. N. H. Slaughter, Mr. E. L. Nelson, Mr. P. H. Evans, Mr. S. E. Anderson and myself.

Q. 141. Where else were these sets operated besides the places you have mentioned, up to the time of the completion of the 7-A receivers, if any where? A. Well, the 7-A receivers were operated at several locations, in addition to the final disposition of one set in Mr. Craft's home. The other set was originally delivered to Mr. J. J. Lyng, now deceased, at his apartment in New York City. The sets were demonstrated in the laboratories to Mr. Craft long before the completion of the 7-A receivers.

Q. 142. Is Mr. Craft alive now? A. No.

Q. 143. Are any of the drawings or memoranda that you have referred to this morning the original drawings on the same sheets of paper as you made them, on the dates given in such memoranda and drawings? A. Exhibit 1-A is the original. Exhibit 1-B is a blueprint recently made from the original tracing which is on file at the laboratories. Exhibit 2 is the original drawing prepared by Mr. Fischer, with my knowledge, on December 30, 1925. The rest of the exhibits, Nos. 3 to 9, inclusive, are photostatic copies of the originals which have been obtained from various files within the Bell Telephone Laboratories.

Q. 144. What did you do with the originals of these papers that you made, at the time you made them? A. It is my remembrance that the originals of Plaintiff's Exhibits 3-A, 3-B and 3-C were forwarded to Mr. J. B. Rawlings, now deceased, of the patent department of the Bell Telephone Laboratories, and these photostatic copies of these exhibits which have been offered in evidence were found in Mr. Rawlings' personal file. The originals, in the case of the other exhibits, would have been turned over to my immediate superior, S. E. Anderson, who would have transmitted these to his superior or to file.

Q. 145. Do you know whether or not a search has been made for the originals of these other papers? A. A search has been made, and the exhibits offered are the earliest editions of photostatic copies that we have been able to locate to date.

Q. 146. What is meant by "A. C." as you have used it and as it appears in some of these exhibits? A. "A. C." is alternating current.

Q. 147. What does an A. C. receiver mean? A. An A. C. receiver is one deriving its necessary operating potentials from an A. C. source, usually through rectification, as in this case. In some A. C. receivers the cathodes are heated indirectly by A. C., the rest of the potentials being derived by rectification.

Q. 148. Do you know whether any of the DDAC receivers are now in existence? A. Yes, two of them are still in existence, one at the home of Mrs. E. B. Craft in Hackensack, New Jersey, and the other in the offices of the patent department of the Bell Telephone Laboratories on Hudson Street, New York City.

Q. 149. Are those the receivers you have referred to as the two 7-A receivers? A. Yes.

Q. 150. Do you know of any other receivers now in existence of the DDAC and 7-A types? A. None of the original models are in existence.

Q. 151. Except the two 7-A receivers? A. Except the two 7-A receivers.

Q. 152. Referring to the photographs which have been marked Plaintiff's Exhibit 9-A to 9-F, inclusive, are they photographs of the set which is now at the Hudson Street place of business of the Bell Telephone Laboratories or are they of the other 7-A receiver? A. I believe they are of the set which is now at Mrs. Craft's home in Hackensack, New Jersey. These pictures were all made at the same time, as indicated by the serial numbers and certain marks which show up on the panel, do not appear on the set which we have at Hudson Street.

Q. 153. Except for those differences, would the photographs in evidence correctly show the other 7-A receiver? A. Yes, the two sets were identical, as far as they could be made.

(Whereupon, at 1 p. m., a recess was taken until 3 p. m., at 250 Hudson Street, New York City.)

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AFTER RECESS.

Met pursuant to adjournment at 3:15 p. m.

Present: Mr. Barnes and Mr. Guild.

*Continuation of the direct examination of PHILANDER H. BETTS, by Mr. Barnes:*

Q. 154. I show you a pencil tracing bearing the notation "Preliminary circuit for a double detection A.C.-operated radio receiver," dated Sept. 9, 1925; drawn, P. H. B.; engineer, P. H. B.", bearing the No. ES-403489. Please tell us what this tracing is. A. This is the original drawing from which the blueprint offered in evidence as Plaintiff's Exhibit 1-B was printed. It was prepared by



me on September 9, 1925, and is referred to in the memorandum offered as Plaintiff's Exhibit 1-A.

IT IS HEREBY STIPULATED between counsel for the respective parties that in place of the original tracing just identified by the witness, a positive photostatic copy thereof may be substituted and used with the same force and effect as the original tracing, and that such positive photostatic copy shall be used in place of the blueprint heretofore marked in evidence as Plaintiff's Exhibit 1-B.

Q. 155. I call your attention to a large console cabinet. Please tell us what that is. A. This is one of the two 7-A radio receivers.

Q. 156. Have you previously referred to these receivers in your testimony? A. I have referred to the 7-A receivers in several places in my testimony, and have offered as Plaintiff's Exhibits 9-A to 9-F, inclusive, photographs of the other 7-A radio receiver, which is substantially the same as the one here.

Q. 157. Is the circuit arrangement of the receiver which you have just identified shown in any of the exhibits heretofore marked in evidence? A. The circuit of this 7-A radio receiver is shown in Plaintiff's Exhibit 8-A.

Q. 158. Is it shown in any other exhibits? A. Plaintiff's Exhibits 8-B and 8-C show other modifications, very slight in nature, that do not appear in this receiver, to the best of my knowledge.

Q. 159. When did you first see the receiver which is now before you in this room? A. Shortly after it was delivered to us from the model shop of the laboratories.

Q. 160. Approximately what time was that? A. The latter part of 1926.

Q. 161. Have you heard this receiver in operation? A. Yes, I have operated both this receiver and the other 7-A receiver.

Q.162. Does this receiver now contain an automatic volume control circuit? A. This receiver, as it now stands, depends entirely upon automatic volume control, having no manual volume control device in it. I mentioned earlier in my testimony that all of the sets did previously have manual volume control, but this was a separate attachment, which this set does not have at the present time.

Q.163. Referring to Plaintiff's Exhibit 8-A, I see the notations "receiver unit, receiver rectifier unit" and "amplifier unit". Can you point out these three units in the receiver before you? A. Yes, they are similarly located in the actual set to the way the circuit is laid out. The receiver unit is on the upper deck and the amplifier unit and the rectifier unit on the lower deck, the rectifier being to the left and the amplifier being to the right; and in that circuit diagram the miscellaneous power equipment is shown in the lower center portion of the diagram, corresponding to its location in the cabinet.

Q.164. In referring to the left and right, you are looking at the front of the receiver? A. That is right.

Q.165. I notice a series of 10 tubes located within this receiver. Will you please state the function of each tube, briefly, and you may stand in front of the receiver and begin with the tubes on the left hand side. A. Reading from left to right, the tubes in the rear row are, respectively, the audio frequency amplifier, the second detector, the third intermediate frequency amplifier, the second intermediate frequency amplifier, and the first intermediate frequency amplifier. In the second row of tubes; that is, the row of tubes toward the front of the set, reading from left to right, the first tube is the control tube or the A. V. C. tube, the second tube is the radio frequency amplifier, the third tube is the fourth intermediate frequency amplifier, otherwise known as the A. V. C. inter-

mediate frequency amplifier tube; the next tube is the modulator or first detector tube, and the last tube is the oscillator.

Q.166. You have referred to the first tube in the front row as the control tube for the automatic volume control, and to the third tube in the same row as the fourth stage of intermediate frequency amplification. Did these two tubes serve any function other than for automatic volume control? A. No.

Mr. Barnes: I now offer in evidence as Plaintiff's Exhibit 11 the radio receiver identified by the witness.

The radio receiver was marked Plaintiff's Exhibit 11 for Identification, January 8, 1935.

Mr. Barnes: Direct examination closed.

By agreement between counsel, cross-examination of Mr. Betts is to be had at a time to be mutually agreed upon.

New York, February 1, 1935.

Adjourned examination of Philander H. Betts, a witness on behalf of the plaintiff, held at the offices of Messrs. Fish, Richardson & Neave, 20 Exchange Place, New York City, before Elizabeth Pritzker, a notary public within and for the State of New York County of Kings (with certificate filed and authorized to act in New York County).

#### Appearances:

Stephen H. Philbin, Esq.,  
Counsel for the Plaintiff;

Mr. J. G. Norton,  
Baldwin Guild, Esq.,  
Counsel for the Defendant.



*Direct examination of Philander H. Betts (continued)*  
*by Mr. Philbin:*

Q. 167. On the previous hearing you produced some photostatic drawings and other papers referring to your work in 1925 and thereafter on superheterodyne receivers, and you stated with respect to the photostatic copies that they were "the earliest editions of photostatic copies that we have been able to locate to date." Since that hearing have you found any originals of any of these drawings? A. Yes.

Q. 168. When did you find these originals? A. January 30, 1935.

Q. 169. Where did you find them? A. In one of the offices of the Bell Telephone Laboratories at their place of business at 180 Varick Street, New York City.

Q. 170. Whereabouts were they? A. They were contained in an unmarked folder in some file cases that originally had contained some of the personal records of Mr. S. E. Anderson, and were at the present time being used by one of the Laboratories' engineers, Mr. G. C. DeCoutouly.

Q. 171. Where had you previously searched for originals of these papers? A. I had looked through my own personal files, both at the Laboratories and at home; had looked through the files of the Patent Department, I had looked through the case folders in which the paper normally would have been formerly filed, and I had looked through the folders belonging to Mr. S. E. Anderson where the other papers in connection with this matter were found.

Q. 172. You stated that the place of business of the Bell Telephone Laboratories was at 180 Varick Street, New York City. Did you look for these papers in any other place of business of the Bell Telephone Labora-

tories? A. In 463 West Street, New York City. I don't know the number of the Patent Department on Hudson Street.

Mr. Norton: 250 Hudson Street.

Q. 173. New York City? A. New York City.

Q. 174. I show you a paper entitled: "Schematic Diagram of DDAC-1 Radio Receiver" bearing the words: "drawn Jan. 13, 1926 by Henry F. Searr, witnessed and understood, P. H. Betts 1/13/26, key connections corrected Jan. 14, 1926, H.F.S., P.H.B." and which appears to be the original of Plaintiff's Exhibit 4-B. Can you identify that paper? A. Yes. I have compared this drawing with Exhibit 4-B, and I am positive that it is the original from which Exhibit 4-B was prepared.

Q. 175. When did you put your initials on this paper? A. On January 13, 1926 and January 14, 1926, as shown by the date and my signature and my initials.

Mr. Philbin: The plaintiff offers in evidence the paper referred to as Plaintiff's Exhibit 4-B-1.

Paper was marked Plaintiff's Exhibit 4-B-1, February 1, 1935.

Q. 176. I show you a paper entitled: "Potential Diagram per Jan. 13, 1926 Schematic DDAC-1 Radio Receiver, PHB, 1-14-26" which appears to correspond to Plaintiff's Exhibit 4-C. Can you identify that paper?

A. This paper is the original showing in ink of the circuit constants as reproduced and offered as Exhibit 4-C, but bearing in addition some pencil modifications.

Q. 177. Where are those modifications? A. Certain of the resistances have been crossed out. Some of the resistance values have been changed; some of the voltage values have been changed, and a change has been made in the connection from one of the resistances.

Q. 178. When were the circuits and original values on

that paper first put on it? A. They were prepared by me and drawn on January 14, 1926.

Q. 179. When were the additions made and changes? A. I don't know.

Mr. Philbin: Plaintiff offers this paper in evidence as Plaintiff's Exhibit 4C-1.

Paper was marked Plaintiff's Exhibit 4C-1, February 1, 1935.

Q. 180. What was Plaintiff's Exhibit 4-C, which appears to be a black photostat, made from? A. Exhibit 4-C appears to have been made from a marked print taken from Exhibit 4C-1, inasmuch as some of the penciled changes shown on Exhibit 4C-1 are also indicated in 4-C.

Q. 181. I show you a paper entitled: "Schematic Diagram of DDAC-2 Radio Receiver" and also having the words "drawn by P. H. Betts" and apparently being the issue 3 of May 19, 1926, and which paper corresponds with Plaintiff's Exhibit 5. Can you identify this paper? A. This is the original drawing prepared by me, from which Exhibit 5 was reproduced. As noted in previous testimony, Exhibit 5 is a marked copy of a photostat showing certain modifications and additional comments.

Q. 182. Referring to the original, did you make that drawing and write the words on it? A. Yes.

Q. 183. When? A. When it was originally prepared as issue 1 as of April 4, 1926 and modified from time to time as shown by the later issues to May 6, 1926 and issue 3, May 19, 1926.

Mr. Philbin: Plaintiff offers in evidence the paper as Plaintiff's Exhibit 5-1.

Paper was marked Plaintiff's Exhibit 5-1, February 1, 1935.



Q. 184. Did you find any other original papers describing the DDAC receivers? A. Yes.

Q. 185. I show you a paper entitled: "Schematic Diagram for DDAC-1 Radio Receiver Circuit Revision of Feb. 26, 1926" with the words on the upper left-hand corner: "change 1, 2, 3", with words thereafter, and bearing your initials and also your name. Can you identify this paper? A. This is the original drawing from which Exhibit 4-E was made while it was in the condition as shown under change number 2.

Q. 186. When did you make this drawing? A. It was originally prepared on March 2, 1926, at which time I signed it, and it was witnessed and understood, as evidenced by the three signatures H. B. Fischer, S. E. Anderson, and H. F. Scarr, and in each case the date after the signature is 3/2/26.

Q. 187. Did you make this drawing? A. Yes.

Q. 188. When? A. The drawing in its present state was last modified by me on March 22, 1926 to show the circuit as change number 3.

Q. 189. When did you first make this drawing? A. March 2, 1926.

Mr. Philbin: Plaintiff offers in evidence this paper as Plaintiff's Exhibit 4E-A.

Paper was marked Plaintiff's Exhibit 4E-A, February 1, 1935.

Q. 190. What are the differences between 4-E and 4E-A? A. Exhibit 4-E is marked photostatic copy bearing certain additions and numerical values for constants which have been added to the photostat. Exhibit 4E-A doesn't bear these constants, and has been modified as shown in a change column "output circuit balanced to ground; errors corrected." The change referred to as output circuit balanced to ground, is a slight modification

of the head 'phone jack connected across the output to the loud speaker. The error, at least one of the errors, which has been corrected, is in a retention of one of the by-pass condensers shown under the vacuum tube designated four. Another error which was corrected was the completion of the dashed line showing the shielding compartments for the oscillator tube, and the radio frequency amplifier and modulator or first detector circuits.

Q. 191. I show you a paper entitled "Schematic Diagram of DDAC-3 Radio Receiver" being apparently issue 3, 4/29/27 and bearing your name and your initials. This paper appears to correspond to Plaintiff's Exhibit 6-B. Can you identify it? A. This is the original from which the photostatic copy offered as Exhibit 6-B was prepared. However, it is of a later issue. Exhibit 6-B was made from this drawing when it was in its second issue as of 10/28/26.

Q. 192. You have spoken of "issues" with respect to this paper and also other papers. What do you mean by issues? A. When a slight modification or correction was made in a diagram the original was corrected or modified and such modification was indicated by the issue number rather than preparing an entirely new drawing. In this particular case we have offered a copy of issue 1 as Exhibit 6-A and issue 2 as Exhibit 6-B.

Q. 193. The original paper you have just referred to has marked on the lower left-hand corner "issue 1, issue 2, issue 3". Does that mean that this paper is a third drawing of these circuits, or that it is the original drawing which has been changed twice? A. It is the original drawing which has been changed twice.

Q. 194. When did you draw the circuits shown on that paper? A. It was originally prepared in 7/23/26 as modified on 10/28/26 and 4/29/27.

Q. 195. Who did that original drawing and modifica-

tions? A. I made the original drawing and I made all of the modifications.

Q. 196. Did you make the original drawing on or before 7/23/26? A. Yes.

Q. 197. And did you make the modifications as of the dates shown? A. Yes.

Mr. Philbin: The plaintiff offers this paper in evidence as Plaintiff's Exhibit 6B-A.

Paper was marked Plaintiff's Exhibit 6B-A, February 1, 1935.

Q. 198. I show you a paper entitled: "Schematic Diagram DDAC-4 Radio Receiver" bearing your name and the date 5/13/27 and also the words "Issue 2-6/13/27" with your initials. This paper appears to correspond to Plaintiff's Exhibit 7. Can you identify this paper? A. This is the original drawing from which Exhibit 7 was prepared when this drawing was in its original form as of 5/13/27. It contains certain other changes which were made 6/13/27 marked issue 2.

Q. 199. When did you draw the circuits shown on this paper? A. On 5/13/27 and modified them on 6/13/27.

Mr. Philbin: Plaintiff offers the paper as Plaintiff's Exhibit 7-A.

Paper was marked Plaintiff's Exhibit 7-A, February 1, 1935.

Q. 200. Did you find any other original drawings of any of the superheterodyne receivers that you worked with in 1925 and thereafter? A. Yes.

Q. 201. Did you find them in the same place and under the same conditions as the exhibits to which you have previously referred today? A. Yes.

Q. 202. I show you a paper containing pencil drawings and words including the following: "Modified by P. H. Betts on or about Dec. 15, 1925, W & U H. F. Scarr



1/14/26." Can you identify this paper? A. This is the original schematic diagram for the AC operated super-heterodyne receiver and is I believe the earliest complete circuit diagram which we prepared for this type of receiver.

Q. 203. Who drew the circuits on this paper? A. I drew the circuits.

Q. 204. When? A. On or before December 15th, 1925.

Mr. Philbin: Plaintiff offers this paper in evidence as Plaintiff's Exhibit 12.

Paper was marked Plaintiff's Exhibit 12, February 1, 1935.

Q. 205. Who put the words on this paper, Plaintiff's Exhibit 12? A. They were all written in my handwriting, with the exception of Mr. Scarr's signature and the W & U and date and the notation "Firing Order from Negative, R-C-M-O-4-A-D-3-2-1." I don't know who put this particular comment on the drawing. The words "Superseded Jan. 4, 1926" are in my handwriting.

Q. 205. What were the modifications that were made by you on or about December 15, 1925? A. As well as I can recollect, the changes were chiefly in the power circuit and the original circuit shown can be seen faintly beneath the vacuum tubes and transformers forming the parts of this power supply. Certain other resistances apparently were shown originally and removed.

Q. 207. Was there any modification made in the automatic control system? A. There appear to be some erasures around the circuits of those tubes but I do not believe that they were modified at that time. Those changes were probably made in making the drawing originally inasmuch as this is the first copy and not a tracing from a previously prepared drawing.

Q. 208. Do you mean that these erasures were made

at the time that you were making the original drawing, and were not made when the drawing was modified on or about December 15, 1925? A. That's right. Those changes were made earlier than the changes indicated, or which I have indicated as having probably been made on December 15th.

Q. 209. What were those changes to which you have referred? A. The transformer connection between the AVC amplifier tube designated 4, and the control rectifier tube designated C apparently was drawn with a simple transformer connection and was changed to show a balanced and neutralized output circuit for that control amplifier tube. This would not in any way affect its operation except as to the type of transformer which was used.

Q. 210. I show you a paper entitled "Tentative Current Sheet per Circuit as of December 15, 1925 DDAC-1 Radio Receiver." Can you identify that paper? A. Yes. This is the first potential diagram which was prepared for the AC operated superheterodyne radio receiver. It doesn't bear my signature nor my initials, but I recognize it as having been one that I prepared and the writing is in my handwriting.

Q. 211. Did you draw the circuits on that paper? A. Yes, I did.

Q. 212. When did you draw those circuits and write the words and the numbers on that paper? A. It was prepared some time after the completion of the circuit diagram offered as Plaintiff's Exhibit 12, but before the circuit diagram of December 30, 1925, offered as Plaintiff's Exhibit 2.

Mr. Philbin: Plaintiff offers this paper as Plaintiff's Exhibit 13.

Paper was marked Plaintiff's Exhibit 13, February 1, 1935.



Q. 213. I show you a paper entitled "Modification of Dec. 30, 1925 Circuit, showing new filtering arrangement, P. H. Betts, Jan. 4, 1926, W & U Henry F. Scarr 1/13/26." Can you identify that paper? A. It is a simplified or DC diagram prepared by Mr. H. B. Fischer and witnessed by myself on January 4, 1926. It is an explanation of the circuit of December 30th as modified on January 4, 1926.

Q. 214. Were those circuits and the words and numbers which are now on the drawing on the drawing at the time that you witnessed it on January 4, 1926? A. Those which are in a hard pencil were on the original drawing, as prepared by Mr. Fischer. The drawing has apparently been modified with a soft pencil since that time.

Q. 215. What are the modifications in soft pencil? A. The meter showing the total rectified current has been moved from a position next to ground to another part of the circuit immediately adjacent to the power supply. A condenser has been added effectively across the power amplifier circuit and is designated as 1 and under that 21 AA, meaning that one microfarad condenser was used. A resistance originally shown as three is crossed out with an X and a numeral 39 has been crossed out. There are several check marks on the drawing indicating that it has been checked with some other circuit or apparatus.

Q. 216. Did any of the modifications relate to the automatic volume control system? A. No, the circuit appears to be entirely unchanged with respect to the tubes designated 4 and C.

Q. 217. What are those tubes? A. 4 was the AVC amplifier and C is the control rectifier.

Mr. Philbin: Plaintiff offers this paper as Plaintiff's Exhibit 14.



Paper was marked Plaintiff's Exhibit 14, February 1, 1935.

Q. 218. By control rectifier did you mean AVC control rectifier? A. Yes, sir.

Q. 219. I show you a paper entitled "Direct Current Diagram per Jan. 4, 1926 circuit DDAC-1 Radio Receiver" and bearing your initials PHB. Can you identify this paper? A. This is a potential diagram corresponding to Mr. Fischer's drawing offered as Plaintiff's Exhibit 14, but drawn by me in order to show all of the necessary parts entering into the direct current network. Mr. Fischer's circuit was only a preliminary one, not being complete.

Q. 220. Who drew the circuits that are now on that paper, and who wrote the words and figures which are now on that paper? A. I did.

Q. 221. When? A. On or shortly after January 4, 1926 and before January 13th, at which time an entirely new circuit was prepared, as offered as Plaintiff's Exhibit 4-C.

Mr. Philbin: Plaintiff offers this paper as Plaintiff's Exhibit 15.

Paper was marked Plaintiff's Exhibit 15, February 1, 1935.

Q. 222. Referring to Plaintiff's Exhibit 10, which is a simplified diagram of the automatic volume control or AVC system of the DDAC and 7A receivers, does that diagram correctly show the automatic volume control systems described in each of the exhibits you have testified regarding today, namely, Plaintiff's Exhibit 4B-1, 4C-1, 5-1, 4E-A, 6B-A, 7-A, 12, 13, 14 and 15? A. Yes.

Mr. Philbin: Direct examination closed.

Mr. Guild: Cross-examination will be postponed to a time mutually to be agreed upon. It is

my present understanding that this will be on Wednesday, February 6th.

Mr. Philbin: Plaintiff has consented to a long postponement, not only of the taking of the direct testimony of the witness, but also of cross-examination, at the request of defendant's counsel. Plaintiff is unwilling to agree to further postponements after Wednesday, February 6, 1935, and notifies defendant that the witness will then be produced at 10:30 A. M. in the office of Messrs. Fish, Richardson & Neave, for such cross-examination as defendant may desire.

Mr. Guild: If the last postponement had not been made this witness would not have been able to produce those exhibits this morning on direct examination, since he says he just discovered them the day before yesterday. The mention I made of continuing on February 6, 1935 is, as I told Mr. Philbin, entirely subject to the engagements of Mr. Davis who has not yet been consulted.

Mr. Philbin: The taking of these depositions has been postponed for several weeks at the request of Mr. Davis. The defendant is represented by several counsel some of whom have tried cases on the patent involved here, and inasmuch as there are several witnesses more to be examined, none of these witnesses being in the employ or under the control of plaintiff, the completion of these depositions will be had as soon as practicable.

Mr. Guild: Defendant has had notice of only one additional witness, namely, Mr. Fischer. If there are other witnesses, it will be helpful to have a list of them.

(Further taking of these depositions adjourned to Wednesday, February 6, 1935 at 10:30 A. M.)



Adjourned examination of Philander H. Betts, held at the offices of Messrs. Fish, Richardson & Neave, Esqs., 20 Exchange Place, Borough of Manhattan, New York City, on Wednesday, February 6, 1935, at 10:30 A. M.

Appearances:

Stephen H. Philbin, Esq.,  
Counsel for plaintiff;

Mr. J. C. Norton,  
William H. Davis, Esq. and  
Baldwin Guild, Esq.,  
Counsel for defendant;

Mr. Langley.

*Cross examination by Mr. Davis:*

Q. 223. Mr. Betts, in answer to some of Mr. Philbin's questions, you spoke of this superheterodyne receiver DDAC-1 as having been built, and then of the modification having been built. In what sense was this receiver built? A. The apparatus was actually constructed in accordance with the circuit diagram, and with reference to the modifications, the modifications could be considered as having been built, but were really added to the first complete set.

Q. 224. Well, the apparatus that you speak of as having been constructed was just standard parts of radio receiving apparatus, wasn't it? A. The radio frequency circuits are not standard parts. We made those up in the laboratory ourselves and in some cases where fixed values of receivers were required they were in a sense special in that they had to be wound up to the predetermined values as required. Perhaps they might be considered as standard units which had been modified. In



that sense the certain elements of the set were constructed and the set as a whole was constructed of the essential parts.

Q. 225. What kind of a cabinet did it have? A. The earliest sets were built on circuit boards, and the circuit boards were contained in a metal case. Later we built a separate metal case and built the apparatus into it. In the sense of a decorative cabinet, there was none in these original sets.

Q. 226. That is, these earliest sets were made up by assembling these parts on an assembly board, is that right? A. That's right.

Q. 227. And then when you made the circuit changes that are indicated on the diagrams that you put in, you just changed the circuit connections on this assembly board? A. Yes, except where changes in apparatus are actually indicated.

Q. 228. And in those cases you took off the old piece of apparatus and put on the new one? A. That's right.

Q. 229. So that each change that you made, as developed in your direct examination, destroyed the identity of the thing that had existed before the change was made? A. That's right.

Q. 230. An examination of these several circuit changes, Mr. Betts, seems to show that you added to Exhibit 1B, that is the superheterodyne receiver without any gain control, that you added to that in the diagram which is Exhibit 2, the two tubes, that is for AVC amplification control, that is the AVC amplifier and the AVC rectifier. That's right so far? A. Yes, sir.

Q. 231. Then examining this Exhibit 2 and the subsequent diagrams, 4-A, 4-B, 4B-1, 4-C, 4C-1, and then a diagram 4-D and then 4-E and 4E-A and then 5, 5-1, 6-A, 6-B, 6B-A, 7 and 7-A, and then Exhibits 8-A, 8-B and 8-C, and then the Exhibits 12 and 13 and then 14 and then 15, it

appears that the changes in the circuit connections involved changes in the serial arrangement of the filaments of the tubes, that is the arrangement that is referred to on one of those diagrams as the "firing order", an analogy, I suppose, to automobile cylinders. Now am I correctly informed that you did change that firing order in these various rearrangements of the circuit? A. Yes, the firing order was changed from time to time. I do not know that they have been changed in all of the exhibits, because I haven't compared them as you have.

Q. 232. Well, now, as I understand it, this series arrangement of the filaments was intended to do away with the necessity, which would otherwise exist, for a separate B battery or source of power in your AVC rectifier amplifier circuits, is that right? A. Yes.

Q. 233. Now, will you tell us why it was that you kept changing this series order of the filaments throughout this period of development? A. The purpose was twofold. One was to achieve a circuit having the minimum overall voltage requirements from a power supply standpoint, and the other was to eliminate the undesirable couplings introduced by the series filament supply. The changes were primarily made to obtain a satisfactory frequency characteristic which was seriously affected by coupling through the filament circuit, caused by the extremely high gain of the intermediate frequency amplifier.

Q. 234. How did this disadvantageous coupling due to the series arrangement of the filaments manifest itself? A. The intermediate frequency characteristic was intended to be a band pass type with sharp cut-offs both on the low and the high side and with a flat top or uniform amplification over a definite range of frequencies. As the result of the couplings introduced between stages through the filament coupling, this desirable fre-



quency characteristic was not obtained until we arrived at the final filament arrangement. It is probable that some of the couplings introduced perhaps a positive effect and other couplings a negative effect, so that they might tend to balance.

Q. 235. And this final satisfactory arrangement was arrived at when? A. I don't know exactly when the last change in filament sequence was made. The final change in filament sequence appears to have been shown on Exhibits 8-A, which is dated 7/12/27.

Q. 236. And am I correct in understanding that this upsetting of the frequency characteristic due to the positive and negative couplings in the series filament arrangement would manifest itself as distortion of the speech in music signals that went through the amplifier? A. Well, that would be a matter of opinion. We were endeavoring in this receiver to make the best possible receiver, regardless of price, and where any improvement could be made, we endeavored to do so. The set as shown in the earliest diagram functioned as a radio receiver.

Q. 237. Well, that didn't have any gain control? A. I mean a receiver constructed in accordance with Exhibit 2.

Q. 238. That is, what you are saying is that the thing functioned as a receiver even when you added the first form of the gain control? A. That's right.

Q. 239. It functioned as a receiver before you added any gain control, didn't it? A. No radio receiver was built up in accordance with Exhibit 1-B. That was a preliminary diagram.

Q. 240. Was it your custom to make up preliminary diagrams before you assembled the parts into a receiver? A. Yes.

Q. 241. Well you don't want us to understand, Mr.



Betts, that you didn't have a superheterodyne receiver corresponding in substance to the signal arrangements in Exhibit 1-B before you added any gain control, do you?

A. Yes. The receiver when first built up in its complete form had the AVC. The parts of the circuit had been individually tested and their characteristics determined, but no complete receiver was built up corresponding to Exhibit 1-B.

Q. 242. When in your memorandum of January 4, 1926, Exhibit 3-B, you wrote the words: "Suggestion for modifier automatic gain control" what previous form of automatic gain control did you have in mind? A. That of the earliest type requiring separate batteries for the control tube.

Q. 243. Well, that earlier form had been developed to your knowledge by the engineers, or I will say had been set up to your knowledge by the engineers? A. The earlier type had been employed for some time by the radio research group working at Cliffwood.

Mr. Philbin: New Jersey?

The Witness: New Jersey.

Q. 244. And you had been acquainted with that work?

A. Very slightly. I had visited the station, but I don't recall having seen that previous automatic volume control set operate as such.

Q. 245. But you knew it had automatic volume control? A. Yes.

Q. 246. And that it had to have separate batteries for the control tubes? A. Yes.

Q. 247. And your suggestion of January 4, 1926 was to modify that in such a way as to do away with the extra batteries, is that right? A. Yes.

Q. 248. What record have you, Mr. Betts, of what led you to make the successive rearrangements of the firing order, I will use that expression, of the filaments? A.

I have no records in that regard. The measurements which were made on the receivers were made by other engineers in the laboratories, and the data is available in their notebooks.

Q. 249. And then would that data be submitted to you and lead you to make a further modification of the circuits? A. Yes and no. I was merely one of the group working on this receiver. My supervisor, Mr. S. E. Anderson, would have dictated the nature of the changes to be made on the basis of information which he obtained from the measurements made by the other members of the group.

Q. 250. I want to get that a little clearer if I can, Mr. Betts. That is, would Mr. Anderson tell you to make certain circuit changes and you would then make them, or would he tell you that the thing was defective in some particular and let you work out how to improve it? A. Sometimes it is one of those cases, sometimes the other, Sometimes we were working more or less on our own, other times under close dictation by Mr. Anderson.

Q. 251. Well, now, take for instance the changes in the circuit arrangement that is represented in the January 13, 1926 diagram, Exhibit 4-A, as compared with Exhibit 2. Do you recall what led you to make those changes, if you did make them? A. That particular filament sequence change was one made at my suggestion in order to obtain a greater plate voltage for the control rectifier tube and to save on the overall required rectified potential. The major change therein is one of placing the control rectifier filament ahead of the filtering chokes so as to employ the potential drop across them as part of the plate potential of the control tube.

Q. 252. Well, you also switched the AVC rectifier filament into first place instead of second place, as it had been in Exhibit 2, did you not? A. Yes.



Q. 253. When I say first place, I mean nearest to negative end? A. Yes. I might say that in Exhibit 2 we followed the practice we previously had with respect to the radio frequency circuit, of having the radio frequency amplifier tube as near ground as possible. That would be the negative end of this filament string.

Q. 254. And in the arrangement of January 13th, Exhibit 4A, you put the AVC rectifier filament at the negative end, and put the radio frequency filament next to it, that is number 2 in the firing arrangement? A. Yes, except that the filter chokes are interposed between the control rectifier filament and the radio frequency amplifier filament, and it will be noted that the ground connection has not been essentially changed with respect to the radio frequency amplifier tube.

Q. 255. Now will you look at Exhibit 4-B of January 13, 1926 and will you tell me whether the changes there as compared with 4-A were made by you, that is, at your own suggestion? A. Exhibit 4-B is a partially corrected diagram similar to 4-A. A change in the key connection was probably made at my suggestion, but Exhibit 4-B is a marked photostat copy of the original tracing and adds certain other circuit elements which apparently were missing from the original tracing, such as the completion of a plate supply for the tube marked four and of the oscillator tube marked O. Those changes were probably made by Mr. Henry F. Scarr who made the original drawing.

Q. 256. Well, you don't know that, do you Mr. Betts? You are just guessing? A. No, sir.

Q. 257. You don't know whether this Exhibit 4-B represents circuits which were actually set up in the receiver that you were working on, or not, do you? A. Well, I know that the receiver was connected up in accordance with that diagram.



Q. 258. Diagram 4-B? A. Yes, sir.

Q. 259. You mean as modified by these pencil lines on it? A. Yes, sir.

Q. 260. So that Exhibit 4-A of January 13th represents one circuit arrangement that was actually made in the receiver, and the Exhibit 4-B represents another? A. I would rather say that 4-A was a photostatic copy of the original before the corrections had been made. We could make diagrams faster than we could modify the apparatus.

Q. 261. Well, then, am I to take that to mean that the arrangement shown in Exhibit 4-A as it stands was never made in the set, or do you remember that? A. No set was made in accordance with Exhibit 4-A, but rather in accordance with 4-B, which was a corrected copy of 4-A.

Q. 262. Well, now, how about 4B-1? A. 4B-1 is the original drawing from which 4-B was photostated, except that there is a correction on the plate circuit of the tube marked four, which apparently had been put on the original since the photostat of 4-B was made. That change escaped my attention when I testified before that 4-B was identical with 4B-1.

Q. 263. Well, the substance of the matter is that 4-A, 4-B and 4B-1, those three exhibits represent only a single rearrangement of the circuits of the receiver, is that right? A. That's right.

Q. 264. Now look at Exhibit 4-D. That's marked "Circuit Revision of February 26, 1926" and it is signed by you on March 2nd, 1926. Do you recall what led you to make that rearrangement in the circuits, if you did make it? A. The changes made as of February 26th were probably indicated as marked copies or photostats similar to Exhibit 4-B and on March 2nd I drew the drawing to show those changes as made.

Q. 265. That is, Exhibit 4-D? A. Exhibit 4-D, yes, to show those changes as of February 26th.

Q. 266. Do you mean that between January 13th and February 26th there had been changes in the circuit arrangements of the receiver which had been noted on other photostats, and that on February 26th you brought together all of these changes into a new drawing, Exhibit 4-D, is that correct?

Q. 267. I notice that in the Exhibit 4-D arrangement the AVC amplifier tube has been put into the tenth place, has been moved to the extreme positive end of the series, whereas in Exhibit 4-A and 4-B it was the sixth place in the series. Can you tell us why that was done and who suggested it? A. This is one of the rearrangements found desirable on account of the effect on the intermediate frequency characteristic. Whose specific suggestion it may have been, I cannot tell.

Q. 268. You mean you don't remember, is that right? A. I don't remember.

Q. 269. Now look at Exhibit 4-E. Do I understand that that was a further modification of the circuit arrangements that are shown on Exhibit 4-D, is that right? A. That's right.

Q. 270. Can you tell us why that rearrangement was made, and what it amounted to? A. The nature of the changes are indicated on the upper left-hand corner of the drawing, marked "change one" and "change two". Under change one it shows that the filament sequence R and O, meaning the radio frequency amplifier and oscillator respectively, were interchanged to reduce filament coupling. In other words, aside from the intermediate amplifier characteristic being affected by filament coupling, we had a similar condition in the radio frequency amplifier circuits. In change two it will be noted that the ground which previously had been asso-



ciated with the radio frequency amplifier tube as closely as possible was moved over to the positive end of the group of series filaments.

Q. 271. Why was that done, do you know? A. I don't know, but I think it may have been in order that the tube next to ground would have the minimum effect on or through coupling to the control tube and in this case the amplifier tube associated with the control tube is the one which is at ground potential for one side of its filament.

Q. 272. Well, do you think that was to reduce the coupling effect with respect to the AVC amplifier or affecting the AVC amplifier? A. Well, probably not to affect the coupling to the AVC amplifier, but to reduce as far as possible the reflection effects of the amplifier 4 associated with the control rectifier C in its effect on the intermediate frequency amplification characteristic. In other words, getting back to the filaments of the amplifiers 1, 2 and 3. Previously the coupling existing in the filament circuit between the control rectifier amplifier 4 and the control rectifier tube itself would pass through the entire filament sequence, whereas in this circuit, as shown in 4-E, we have the four microfarad condenser coupling the two filaments together, and by having the filament circuits arranged as shown the effect on the frequency characteristic was minimized.

Q. 273. That is the effect of the volume control apparatus on the intermediate frequency characteristic? A. That's right.

Q. 274. Well, that change then was made with the same end in view that subsequently led you to connect the wires leading to the AVC amplifier across the secondary of the detector instead of across the primary? A. You mean across its output instead of its input?

Q. 275. Yes. A. Not entirely. By connecting it across



the output of the detector instead of the input we were able to make use of the added connection of the second detector, that is, the added connection at intermediate frequency. In that connection we could couple on more loosely to its plate circuit and still get more drive for the control rectifier amplifier tube 4.

Q. 276. But one of the reasons for connecting the AVC amplified across the detector output was, I think, to minimize the reflection on the characteristics of the intermediate frequency? A. Yes, sir.

Q. 277. And that was the same difficulty that caused you to make this change in Exhibit 4-E that we have just been speaking of? A. Yes, sir.

Q. 278. Now if you look at Exhibit 5, am I correct in understanding that there were three issues of this, dated respectively April 24, 1926, May 6, 1926 and May 19, 1926? A. Yes.

Q. 279. And that each of those issues represents a different rearrangement of the circuits? A. I don't remember what the nature of the changes was between those various issues. Possibly it was for the purpose of adding information not shown, because—

Q. 280. I wonder if we ought to go into the possibly's. As I understand, you don't know now whether there was a change in the circuits or not, is that right? A. That's right.

Q. 281. What is your recollection about the changes that are shown in the Exhibit 6-A of July 23, 1926? A. Well Exhibit 6-A is a marked copy of a photostat and I assume you refer to the markings which are in that photostat. They were not made by me.

Q. 282. You don't know whether they were made in the set or not? A. No, I cannot testify in that regard.

Q. 283. Well, what do you know about the Exhibit 6-B? A. Similar to 6-A, this is a marked copy of a

photostat and the changes shown therein were actually incorporated in the receivers. Part of the changes as indicated were for the simpler understanding of the circuit by Mr. B. O. Browne, who was the mechanical designer connected with this job. It will be noted that this photostat copy was his property, having his name at the top.

Q. 284. Well, you drew the original diagram, as I understand it? A. Yes, sir.

Q. 285. And what is the significance of the two entries in the lower left-hand corner: "Issue 1-7/23/26 and Issue 2-10/28/26"? A. Well, Exhibit 6-A without the obvious modifications would be a photostat of the original drawing, and Exhibit 6-B would be a photostat of the changes incorporated in Issue 2 as of 10/28/26. It may be readily compared.

Q. 286. Now what, if you know, is the significance of the entry in the left-hand corner which reads  $R_1$  to 11.7  $R_s$  to 38-R, R29 added—January 3, 1927. Is that your entry? A. No, sir.

Q. 287. Well, you don't know what its significance is? A. I believe that those entries were made by Mr. B. O. Browne in connection with changes which were made later than the original drawing as of Issue 2,  $R_1$  to 11.7 would be his designation for the circuit elements or the physical pieces of apparatus in the sets. Two sets were actually built up, having all of these changes, as shown, beginning with Exhibit 5, etc., so that by the time we got to Exhibit 6-B, the tracing for the original was made and modified as Issue 2-10/28/26 and certain other changes were made from time to time as indicated by Mr. Browne on this marked copy on January 3, January 10, January 24th and January 26th, 1927.

Q. 288. Then the third issue of that drawing which is dated 4/29/27 is Exhibit 6B-A, is that right? A. Well,



6B-A is the original drawing from which this other exhibit was prepared when it was in the condition as of Issue 2 on 10/28/26.

Q. 289. Let's strike that out. I am looking at this Exhibit 6B-A, that is the third issue? A. That's right. That is the original drawing as shown in its issue 3 as of 4/29/27 and is the original from which Exhibit 6-B was prepared when the original was in its second issue.

Q. 290. See if I can state that correctly. You started off with the drawing of July 23, 1926, which is Exhibit 6-A, that is, from which Exhibit 6-A was photostated, and then changes were made on Exhibit 6-A as shown? A. Yes, sir.

Q. 291. Then there was a second issue of that original drawing which was made on 10/28/26, and Exhibit 6-B is a photostat of that second issue, with further changes made on it in pencil? A. Yes.

Q. 292. And Exhibit 6B-A is the third issue of the original drawing, and it is dated 4/29/27, is that right? A. That's right.

Q. 293. Well, now, I want to ask you, does the Exhibit 6B-A, the third issue of 4/29/27 embody all the changes that were made in the interval between July 23, 1926 and April 29, 1927, or does it merely embody the final arrangement as it stood on or about April 29, 1927? A. No, 6B-A doesn't embody those explanatory markings which Mr. B. O. Browne put on 6-B. In other words, 6B-A is still a drawing showing the electrical circuit design and the additions which Mr. B. O. Browne added to Issue 2 were for the identification of the physical pieces of apparatus. Those designations are not shown in 6B-A.

Q. 294. Well, what is the difference between Issue 2 of 10/28/26 and this Issue 3 of 4/29/27, which is Exhibit 6B-A? A. Well, between Issue 2 and Issue 3 a resistance and a small capacity was added to the coupling cir-



cuit between the radio frequency amplifier tube and the modulator or first detector tube. These changes are shown added to Exhibit 6B and then incorporated in Exhibit 6B-A. Some of the apparatus designations have been changed, I note one on 6-B in which Mr. Browne has marked out W6738 and written in W6836. The latter number now shows on 6B-A.

Q. 295. I don't want you to spend the time, Mr. Betts, to assure yourself that you checked up all the changes. We won't hold you responsible for that. What I am really trying to get at is whether the Exhibit 6B-A represented the circuit arrangement as it had been developed up to April 29, 1927. A. Yes, that's correct.

Q. 296. Now what did Exhibit 7, May 13, 1927, represent? A. Exhibit 7 is a photostatic copy prepared from Exhibit 7-A and containing other notations as to apparatus designations added probably by Mr. B. O. Browne.

Q. 297. What is Exhibit 7-A? A. That's the schematic diagram of the receivers, including all the changes up to June 13th, 1927.

Q. 298. Now Exhibit 7 is not a photostat of the second issue of Exhibit 7-A, is it? A. That is a photostat copy of issue one of that drawing, and issue 2, dated 6/13/27, shows the changes made in set number 2. I believe at that time the two sets were not identical and that one set was strictly in accordance with issue 1 and the other in accordance with issue 2. The changes are very minor between them.

Q. 299. Then you get that belief from the entry there over your initials on Exhibit 7-A, which reads: "with changes per set number 2", is that right? A. Yes, and my independent recollection is that the two receivers were alternately being loaned out on demonstration, and we were unable to get them both back in the laboratory at the same time to make them identical.

Q. 300. Well, on these sets in these circuit arrangements of Exhibit 5 to 7-A inclusive, the AVC amplifier was in the ninth place and the first audio frequency amplifier filament in the tenth place, whereas in the circuits of Exhibits 4-E and 4E-A those two filaments had been reversed, that is, the AVC amplifier was in the tenth place and the first audio frequency amplifier in the ninth place. Do you recall why that was done? A. No, I don't recall the reason for that particular change.

Q. 301. Now, will you look at Exhibit 8-A of July 12, 1927? In that arrangement the AVC amplifier filament has been returned to the tenth place and the first audio amplifier filament returned to the ninth place. Do you have any recollection of why that change back was made?

A. Yes. In this connection the gain for the amplifier, the fourth amplifier, was to be varied by resistance connected across this filament, indicated there as variable between 483 and 45 ohms, and for mechanical reasons it was desired to have one end of that resistance at ground potential. I assume that was the reason why that change was made, so as to bring the fourth amplifier back so that one side of the filament was grounded.

Q. 302. Were you continuously assigned to work with this radio receiver from January, 1926 to July, 1927, inclusive? A. Yes, but not exclusively.

Q. 303. Were instructions issued to you by Mr. Anderson to make these changes, or any of them, that is, I mean written instructions? A. No, sir, they would have been verbal.

Q. 304. Well, isn't there any written evidence of the considerations which led you to make these changes throughout that period from January, 1926 to July, 1927? A. Well, I don't remember just what written memoranda there may have been discussing the difficulties involved in making these changes.



Q. 305. Well, you never made any search for any such memoranda? A. I have searched for them and I have read the memoranda. I do not recall what each of those things may contain. I personally did not write any.

Q. 306. Then there are memoranda which you have seen which do indicate considerations which led to the making of these changes? A. Yes.

Q. 307. And throughout this period there were repeated changes in the firing arrangement of these series filaments, were there not? A. Yes, sir.

Q. 308. And the purpose of putting those filaments in series was to do away with the necessity for an extra battery in the plate filament circuit of the AVC detector and amplifier? A. Yes, sir.

(At this point there was a conference by counsel.)

Q. 309. You have spoken, Mr. Betts, about an earlier form of AVC control that was being used by a group of the engineers at Cliffwood, New Jersey? A. That's right.

Q. 310. Was that a superheterodyne receiver? A. I believe so.

Q. 311. Will you look, please, at the circuit diagram of January 13, 1926, Exhibit 4-A. That seems to indicate a change of the AVC amplifier grid bias, is that right? A. Do you mean that the circuit had been changed on the diagram?

Q. 312. Well, no. I mean that this diagram as compared with what went before it, Exhibit 2, indicated that the AVC amplifier grid bias was changed, is that right? A. On Exhibit 4-A the control for the output level was changed from the earlier model so that the level was controlled by a change in the grid bias of the control rectifier amplifier tube 4. In the earlier circuit as of December 30th the change in the level was accomplished in a different way.



Q. 313. Mr. Philbin asked you the other day, after referring to this diagram of January 13, 1926, he asked this question: "Q. 54. When was that modified January 13, 1926 receiver built, about?" and you said: "The latter part of December." Now as I understand it, the arrangement of January 13, 1926 was brought about by modifying the receiver that is represented by Exhibit 2? A. That's right.

Q. 314. There was no new receiver built according to the sketch of January 13, 1926? A. No.

Q. 315. Now I'd like to get, if I can, Mr. Betts, just the significance to you of Mr. Philbin's question and the proper significance to us of your answer. Mr. Philbin said: "When about?" and you answered: "The latter part of December." Now I ask you when that change was made? I want your own knowledge of when the change represented in the sketch of January 13, 1926 was actually made? A. Well, the change was made either on January 13th or 14th.

Q. 316. Well, then, you were mistaken when you said the other day that it was made in the latter part of December? A. No, the question which I was answering was a continuation of Q. 53, was a receiver built, and the receiver was built in December but was modified in January in accordance with this diagram, and as stated in my answer to Q. 53, it was not a separate receiver built as of January 13th.

Q. 317. Yes, but Mr. Philbin asked you, Mr. Betts, "Was a receiver built in accordance with the January 13th, 1926 diagram?" You said, "not as a separate receiver, the original one was modified in accordance with that diagram." Now that is correct, isn't it? A. That's right.

Q. 318. Then he said: "When was this modified January 13, 1926 receiver built, about?" and you said: "The

latter part of December." Now I understand you didn't mean that the modification represented by the sketch of January 13, 1926 was built into the set in the latter part of December, but, on the contrary, meant that the original set which had been built in the latter part of December was modified on or about January 13, 1926 to correspond with the Exhibit 4-A, is that right? A. That's right.

Q. 319. You testified the other day that the circuit of the 7-A radio receiver is shown in Exhibit 8-A. Have you checked that diagram with the receiver as it now stands, Mr. Betts, or not? A. If you mean the receiver as it now stands, the actual set that was offered in evidence, it is not in accordance with Exhibit 8-A, but rather in accordance with 8-C less the penciled modifications.

Q. 320. Well, now, I want to know, in your testimony on page 46 Mr. Philbin first called your attention to a large console cabinet.

Mr. Philbin: It was Mr. Barnes. Mr. Barnes—and you said that it was one of "the two 7-A radio receivers" and then you said that Exhibits 9-A to 9-F inclusive were photographs of one of these 7-A receivers. That is all right, so far, is it?

A. Yes, sir.

Q. 321. And Exhibit 11 is that 7-A receiver which is shown in the photographs, Exhibits 9-A to 9-F, as I understand it, is that right? A. No. In my reply to Question 156 I stated that these photographs were of the other radio receivers, not the one offered in evidence as Exhibit 11.

Q. 322. And the large console cabinet to which your attention had been directed by Mr. Philbin, rather Mr. Barnes, was Exhibit 11, was it? A. That's right.

Q. 323. Well, then, having directed your attention to the large console cabinet Exhibit 11 which was one of the 7-A receivers, and then having directed your attention to

photographs of the other 7-A radio receivers, Mr. Barnes asked this question: "Q. 157. Is the circuit arrangement of the receiver which you have just identified shown in any of the exhibits heretofore marked in evidence?" and you said: "The circuit of this 7-A receiver is shown in Plaintiff's Exhibit 8-A."

Q. 324. Now which of these 7-A receivers did you mean when you said "this" 7-A radio receiver? A. My previous reply was an error. Neither of the two 7-A receivers as they now exist was strictly in accordance with Exhibit 8-A but more closely followed the Exhibit 8-C.

Q. 325. Well, you said the other day that 8-C showed slight variations which "to the best of my knowledge" are not embodied in the 7-A radio receiver, Exhibit 11, and I now ask you whether you had checked the circuit as it now stands in Exhibit 11, with either one of these diagrams, Exhibits 8-A, 8-B and 8-C, and whether any of them correctly shows the present circuit arrangements. A. I have checked the circuits of Exhibit 11 and I have compared them with the Exhibits 8-A, 8-B and 8-C, and in all essential details the set has circuits similar to Exhibits 8-B and 8-C. It will be noted that Exhibit 8-B is a marked photostatic copy of the original drawing in which a certain coil and condenser have been added in the plate circuit of the radio frequency amplifier tube. The set had these physical units present, but they had been disconnected. The resistance shown to the right of those added elements was originally I believe 400 ohms. It is not distinct on the exhibit, and this was changed to 2,000 ohms. The 2,000 ohms unit is in the set; the 38W resistance shown approximately in the middle of the diagram about under the second R in receiver—

Q. Yes. A. —was in the set at one time, but was removed from the circuit.

Q. 326. Will you look now again at Exhibit 3-A of



January 2, 1926, where you wrote down "Suggestion for DC amplifier work, the required A B and C are furnished by one high tension source, battery, or rectified AC".

Was that suggestion original with you? A. Yes.

Q. 327. Did you ever execute an application for patent including that suggestion? A. Personally I did not.

Q. 328. Well, do you know whether anyone in the organization applied for a patent containing that suggestion? A. I don't know whether they did or not.

Q. 329. Was there any discussion that you took part in with respect to filing an application for patent on that suggestion? A. None that I recall.

Q. 330. You don't recall any discussion at all of getting a patent on this suggestion? A. Not on this circuit as limited to a DC amplifier. It was not apparatus actually built. The suggestion was tied up directly with the radio receiver circuits.

Q. 331. I am afraid I don't understand that, Mr. Betts. You mean that this suggestion of January 2nd was tied up directly with the radio receiver circuits? A. Well, on page 2 of the exhibit, the last paragraph: "This circuit was evolved in developing the automatic gain control for the DDAC-1 receiver, which is in effect one stage of DC amplification" and any further explanation of that was contained in Exhibit 3-B.

Q. 332. Yes. Now what I am asking you is whether you ever applied for a patent or discussed applying for a patent which contained or in any way disclosed your suggestion for modified automatic gain control in which a single source of EMF replaced a plurality of sources? A. No.

Q. 333. You don't remember ever having any discussion about applying for a patent on that idea? A. No.

Q. 334. Neither in a radio receiver set or any other arrangement? A. No.

*Redirect examination by Mr. Philbin:*

Q. 335. You spoke of arranging the filaments in series and of making changes in that order from time to time and that one of the reasons for doing so was to improve the intermediate frequency characteristic. Did you mean by that the reason was to improve the fidelity of the receiver? A. Yes.

Q. 336. What do you understand to be meant by fidelity? A. Well, fidelity—

Mr. Davis: I really should have asked that question.

—fidelity of the receiver would mean the overall frequency characteristic for modulator radio frequency in the antenna connection to the receiver, to the output terminals and the loud speaker.

Q. 337. How much difference in the fidelity did these various changes make?

Mr. Davis: Well, I will object to that, Mr. Philbin, unless you show that there are no real records of what real difference it would make. I don't want Mr. Betts' hearsay testimony about it.

Q. 338. Do you know what effect on the fidelity those different changes in the so-called firing order, made? A. Well I have seen the frequency characteristics.

Q. 339. Where? A. Before and after those changes were made.

Q. 340. Did you operate a set or hear it operated? A. Yes.

Q. 341. With different firing orders? A. Yes.

Q. 342. Did you notice by ear any difference in the fidelity with different arrangements of the firing order?

Mr. Davis: I object to that. In the absence of the available records of what difference actually

was made, I object to that question.

Mr. Philbin: Will you read the question?

(Question repeated by the stenographer.)

Mr. Philbin: Will you answer that, Mr. Betts?

A. Well, the change in the fidelity would be relatively slight, although a measurable change would have been made.

Q. 343. Do you mean by "measurable" an amount measurable by your ear or by laboratory instruments? A. By laboratory instruments rather than by oral observation.

Q. 344. I again ask you, could you tell the difference by your ear with respect to fidelity when different firing orders were employed? A. Not always. Some of the changes created enough effect on the fidelity to be noticeable or so that I could notice it.

Q. 345. When the firing order was such as to be most harmful to fidelity how did the set in that condition compare with such broadcast receivers as of that date as you were familiar with?

Mr. Davis: I object to that as incompetent.

Mr. Philbin: Answer the question.

Mr. Davis: Answer it.

A. Well I believe at its worst the set was better than those radio receivers on the commercial market.

Q. 346. You mean at its worst with respect to fidelity?

A. That's right.

Q. 347. What commercial broadcast receivers were you then familiar with? A. Oh, there were quite a number of neutrodyne and TRF sets, the Garod, Freed Eisman and the Radio Corporation receivers.

Mr. Davis: We won't accept that as a standard, Mr. Betts.

A. —I don't recall the code numbers at the present time,



early RCA sets.

Q. 348. Any other sets, Atwater-Kent, Stromberg-Carlson, Fada? A. Well, I heard examples of all of those.

Q. 349. Did you have any standard with respect to fidelity, with which the set as it was to be produced was to comply with? A. Yes.

Q. 350. What was that standard? A. The set in its final state was to have as flat a characteristic as possible up to 5,000 cycles and to have as sharp a cut-off above that frequency as possible. There was no control such as now used or commonly called tone control, affecting the upper cut-off frequency. The intermediate frequency characteristic was essentially band pass and the audio frequency circuits were peaked at the high frequency and to make up for the attenuation of the radio frequency circuits which were used inasmuch as we didn't have at that time radio frequency filter networks.

Q. 351. You said you used a flat characteristic about 5,000 cycles and a sharp cut-off. Can you give us any figures or an idea as to how sharp that cut-off was to be? A. I am afraid I don't recall the characteristic which we finally obtained. Inasmuch as we used to get as much attenuation above that frequency as possible, we had no definite figure to shoot for, except one of a reduction of what is now called the image frequency. The five cycle cut-off was desirable or was stipulated as a requirement due to the probable use of this receiver for long distance reception, and the fact that the stations were separated by 10,000 cycle intervals. This meant that audio frequencies of greater than 5,000 cycles might cause interference with an adjoining channel.

Q. 352. You were asked about Plaintiff's Exhibit 6-A, a schematic diagram of the DDAC 3 radio receiver, issue 1, 7/23/26. Was a receiver constructed in accordance with the circuits as now shown on this exhibit? A. At

least one of the two sets which we have referred to as 7-A receivers had this circuit diagram at one time.

Q. 353. But you did not, as I understand it, make all the notations that now appear on this exhibit? A. No.

Q. 354. Referring to Plaintiff's Exhibit 6B-A, which contains a circuit diagram, and is also marked on the lower left-hand corner: "Drawn by P. H. Betts, Issue 1, Issue 2, Issue 3, etc.", when were the circuits that are now on that piece of paper put there? A. Excepting for the lightly pencilled notation above the audio frequency transformer W6836, which reads: WO478, 1-2-456, this drawing was completed on 4/29/27.

Q. 355. When was the drawing commenced? A. July 23, 1926.

Q. 356. How much was added to this piece of paper after the date of 7/23/26? A. That would require careful comparison with the photostats as shown in 6-A and 6-B, which were made from issue 1 and issue 2, but the difference between issue 2 and 3, I think I have mentioned some of those changes already.

Q. 357. Is my understanding correct, that the piece of paper upon which are various circuits and notations, and which is Plaintiff's Exhibit 6B-A, is the original sheet of paper containing the same original circuits placed there on 7/23/26, with, added to that same piece of paper, various changes and modifications indicated by issue 2 and issue 3 notations? A. Yes.

(At 1 P. M. a recess was taken for lunch to 2 P. M., but the adjourned examination did not commence until 2:25 P. M.)

*Redirect examination continued by Mr. Philbin:*

Q. 358. Did any of the changes in the filament firing order affect substantially the operation of the automatic volume control system?

Mr. Davis: I object to that as leading.

A. No.

*Re-cross examination by Mr. Davis:*

Q. 359. Mr. Betts, how is this excellence of this receiver with regard to fidelity attained? A. I believe I explained that before, that the immediate frequency characteristic was essentially band pass, having a flat top characteristic, and that in the audio frequency circuits we compensated for the loss of the audio frequency components, that is the set which is introduced by the radio frequency circuits.

Q. 360. But how is that result attained? A. By partial resonating of the audio frequency transformers.

Q. 361. It wasn't attained by the volume control? A. No.

Q. 362. In fact, volume control interfered with it, and that was one of the reasons that you switched around the firing order to prevent that interference, wasn't it? A. It did at first, until we got the final arrangement.

Q. 363. I understand that this set wasn't designed for competition with the ordinary radio receiver home sets that were on the market, such as the neutrodyne sets you mentioned, was it? A. Not for price competition, no.

Q. 364. Is there a system in the laboratories in which you work by which the ideas developed by the engineers are brought to the attention of the patent department? A. Yes.

Q. 365. And do you know whether this idea was brought to the attention of the patent department? A. Which idea?

Q. 366. This suggestion that is referred to in the first paragraph of Exhibit 3-A under date of January 2, 1926, that is, the suggestion for DC amplifiers, or the sugges-



tion for modified automatic gain control, either one, in which he used a single source instead of a plurality source of energy? A. I regret to say that it did not pass through normal channels. The original of that memorandum was handed by me personally to one of the attorneys of the laboratories, Mr. Rawlings, now deceased, and the only copy which we have of that memorandum is this photostatic copy, which we have offered as the exhibit, which was found in Mr. Rawlings' personal file.

Q. 367. But wasn't this receiver as a whole brought to the attention of the Patent Department? A. Oh, yes.

Q. 368. So they had an opportunity to know what was contained in it and to pass judgment on whether or not to patent it? A. Yes.

Q. 369. Do you know why the decision not to patent it was made? A. No.

Q. 370. Was the circuit arrangement of this receiver ever published by you? A. No.

Q. 371. And no receivers other than those that have been referred to in your testimony were ever built containing that arrangement? A. Containing that exact arrangement. Other receivers embodying the principles therein have been built since that time.

Q. 372. I understood you to testify that none of the receivers embodying this arrangement were ever sold, is that right? A. Neither of the two sets which culminated this development work was sold.

Q. 373. And neither one of the repeatedly modified preliminary development sets was ever sold, was it? A. No.

*Re-direct examination by Mr. Philbin:*

Q. 374. In your answers to the last questions as to whether sets embodying this arrangement were sold, were those answers with respect only to your own knowledge

or were you purporting to speak for the Bell Telephone Laboratories or Western Electric Companies or other concerns? A. I was speaking only of my own knowledge.

Q. 375. Do you know whether any sets containing automatic volume control have been sold by Western Electric or Bell Telephone Laboratories? A. Yes.

Mr. Davis: I object to that.

Q. 376. How do you know? A. Through my present work with the laboratories I have been concerned with the commercial problems involving engineering complaints, and I have handled several complaints involving radio receivers defective for one reason or another, which have been sold and which embody automatic volume control.

Mr. Davis: I have one question here which perhaps you can't answer offhand. If not, I wish you'd get me the information.

Q. 377. Will you please give us the value in ohms of the rectifier load resistor used in each of the circuits represented by the following exhibits: Exhibit 4-A, 4-B, 4B-1, 4-C, 4-D, 4E-A, 5, 5-1, 6-A, 6-B, 6B-A, 7, 7-A, 8-A, 8-B, 8-C, 12 and 14? A. I am afraid I can't answer all those points right off the reel, but I can tell you it varied from time to time from values probably in minimum of 40,000 ohms up to a half million ohms, but in general the way the final set is arranged it had 100,000 ohms. Is that close enough, or do you want a specific reply to each one of those items?

Mr. Davis: I would like a specific reply and if it is agreeable to Mr. Philbin we can add to the record.

Mr. Philbin: Yes.

(Whereupon at 3:10 P. M. an adjournment was

taken to Monday, February 11, 1935, at 10:30 A. M.)

Adjourned examination held at the offices of Messrs. Fish, Richardson & Neave, 20 Exchange Place, Borough of Manhattan, New York City, on Monday, February 11, 1935, at 10:30 A. M.

APPEARANCES:

STEPHEN H. PHILBIN, Esq.,  
Counsel for plaintiff;

BALDWIN GUILD, Esq.,  
Attorney for defendant;  
MR. LANGLEY.

HERBERT B. FISCHER, being first duly sworn, testified as follows:

*Direct examination by Mr. Philbin:*

Q. 378. Please state your name, residence and occupation. A. Herbert B. Fischer, residence 8 Normandy Boulevard East, Morristown, New Jersey, occupation, member of technical staff, Bell Telephone Laboratories.

Q. 379. How long have you been connected with the Bell Company? A. Since August, 1924.

Q. 380. What were your duties with that Company in 1925? A. Work in connection with the development of radio receivers.

Q. 381. Who was your superior? A. My immediate superior was S. E. Anderson.

Q. 382. Did you have anything to do with the develop-



ment or construction of radio broadcast receivers then known as the DDAE receivers? A. Yes.

Q. 383. What were your activities, generally speaking, with respect to those receivers? A. I assisted in the wiring up of the various experimental models and the various laboratory measurements made on these sets.

Q. 384. I show you a paper, Plaintiff's Exhibit 2, bearing the words: "Drawn Dec. 30, 1925 by H. B. Fischer" as well as other words. Can you identify this paper? A. Yes, that is a sketch of an AC operated radio receiver prepared by me at that time.

Q. 385. Was such a radio broadcast receiver built? A. There had been a model built prior to the time of making this sketch.

Q. 386. And in accordance with the circuits shown on that sketch? A. That is correct.

Q. 387. Was that receiver operated prior to December 30, 1925? A. Yes, it was.

Q. 388. Was the operation witnessed by you? A. Yes, it was.

Q. 389. In that operation did the automatic volume control arrangement function? A. Yes.

Q. 390. How did it function, that is, did it function badly or well, the automatic volume control part of the set? A. It functioned in a very satisfactory manner.

Q. 391. I now show you Plaintiff's Exhibit 3-A, a memorandum dated January 2, 1926 entitled: "Suggestion for D. C. Amplifier" and bearing on the second page at the end the following: "The above circuit Fig. 3 is substantially the same as explained to and understood by the undersigned on or prior to Nov. 28, 1925, H. B. Fischer, S. E. Anderson, Henry F. Scarr." Can you identify that memorandum, which appears to have been written by P. H. Betts? A. Yes, that is my signature.

Q. 392. When did you first see that memorandum? A.

Mr. Betts showed the original of this memorandum to me, either the day on which he had prepared it, or a day or two subsequent to that.

Q. 393. Did you write your name on that memorandum, as indicated thereon? A. Yes.

Q. 394. When? A. Well, there is no date given after my name, but, as I said previously, it would be either the date on which Mr. Betts signed it or a day or two following that.

Q. 395. Do you mean by that, it would be on or about January 2nd, 1926? A. Yes, that is correct.

Q. 396. I show you Plaintiff's Exhibit 3-B, another memorandum, dated January 4, 1926, entitled: "Suggestion for Modified Automatic Gain Control to use one source of e. m. f. in place of A, B and C batteries," apparently made by Betts, and bearing at the end the words: "H. B. Fischer 1/4/26." Can you identify that memorandum? A. Yes.

Q. 397. Did you write "H. B. Fischer" on that paper? A. Yes, that is my signature.

Q. 398. When did you write your name on that paper? A. The date on which my name was signed is 1/4/26.

Q. 399. Did you sign your name there? A. Yes, I did.

Q. 400. I show you another memorandum, Plaintiff's Exhibit 3-C, also apparently written by Betts, and having at its end: "H. B. Fischer 1/4/26." When did you first see that memorandum? A. On the day on which it was signed, which was 1/4/26.

Q. 401. Did you write your name on that memorandum? A. Yes, I did.

Q. 402. When? A. On 1/4/26.

Q. 403. I show you Plaintiff's Exhibit 4-B, entitled: "Schematic Diagram of DD AC-1 Radio Receiver, drawn Jan. 13, 1926 by Henry F. Scarr. Witnessed and under-

stood P. H. Betts 1/13/26. Key connections corrected Jan. 14, 1926 H. F. S. P. H. B." When did you first see this paper? A. On the day on which it was drawn, or perhaps a day or two following.

Q. 404. How did you fix that date? A. The day is fixed by the fact that I was working on the models of these radio receivers practically continuously, and would undoubtedly use this schematic in making the wiring changes indicated at about the time it was drawn up.

Q. 405. I show you Plaintiff's Exhibit 4-E, entitled: "Schematic Diagram for DDAC-1 Radio Receiver Circuit Revision of Feb. 26, 1926" and bearing the words: "Witnessed and understood by: H. B. Fischer 3/2/26." Can you identify this exhibit? A. Yes, it was signed by me on 3/2/26.

Q. 406. Was that diagram then also understood by you? A. Yes, it was.

Q. 407. The exhibit I have just shown you was a photostat copy and I now show you Plaintiff's Exhibit 4E-A, which appears to be the original drawing. Can you identify it? A. Yes. It has my name and the date of signing as 3/2/26.

Q. 408. I show you Plaintiff's Exhibit 14 entitled: "Modification of Dec. 30, 1925 circuit showing new filtering arrangement, P. H. Betts Jan. 4, 1926," and at the lower right hand corner the words: "H. B. Fischer." Can you identify that paper? A. Yes. My signature is given on the lower right hand corner.

Q. 409. When did you put your signature on that paper? A. There is no date given, but it would be some time during the early part of January, 1926.

Q. 410. I notice on this paper the words: "Superseded Jan. 13, 1926." Does that aid you or enable you to fix the date more closely than the early part of January, 1926? A. That would mean that this sketch was made prior to that date.



Mr. Guild: I object to that as incompetent.

Q. 411. I show you photostats of certain photographs, Plaintiff's Exhibits 9-A to F inclusive, appearing to be photographs of a radio receiver. Can you identify those photographs? A. Yes, all of these photographs show various views of the 7-A radio receiver.

Q. 412. When did you see such photographs first? A. Shortly after the time that they were taken.

Q. 413. About when was that? A. I am not sure of the exact date of making this model of the 7-A receiver.

Q. 414. Was it 1925, 1926 or 1927? A. It would be either late in 1926 or early in 1927.

Q. 415. I call your attention to Plaintiff's Exhibit 8-C entitled: DDAC-5 Schematic Diagram for the 7-A Radio Receiver" and dated 7/12/27 in issue 2. Does that aid you or enable you to fix the date as to when you first saw these photographs of the 7-A receiver? A. The date given on issue 2 fixes this schematic diagram as 7/15/27, and would indicate that the 7-A receiver, as shown on those photographs, had been constructed at, about or somewhat previous to that date.

Mr. Guild: That question and answer are objected to because the witness has shown no knowledge whatever of Exhibit 8-C.

Q. 416. What knowledge have you concerning Exhibit 8-C, that is, have you ever seen that circuit diagram before? A. Yes.

Q. 417. When? A. I saw this diagram at about the time it was made by Mr. Betts, as I used it in working on the 7-A receiver.

Q. 418. I show you now various circuit diagrams of the DDAC receivers, some being originals and some being photostats, and I will ask you with respect to each whether at this time you can identify any one or more

of them, answering yes or no with respect to each: Plaintiff's Exhibit 4-A, Schematic Diagram of DD-AC-1 Radio Receiver, drawn Jan. 13, 1926? A. Yes.

Q. 419. Plaintiff's Exhibit 4-B, Schematic Diagram of DD-AC-1 Radio Receiver, drawn Jan. 13, 1926, with the words "Key connections corrected Jan. 14, 1926?" A. Yes.

Q. 420. Plaintiff's Exhibit 4-C, Potential Diagram per Jan. 13, 1926, Schematic DDAC-1 Radio Receiver? A. Yes.

Q. 421. Plaintiff's Exhibit 4-D, another photostat copy, entitled: "Schematic Diagram for DDAC-1 Radio Receiver, Circuit Revision of Feb. 26, 1926?" A. Yes.

Q. 422. Plaintiff's Exhibit 4-E, Schematic Diagram for DDAC-1 Radio Receiver, Circuit Revision of Feb. 26, 1926, bearing at the upper left hand corner Change 1 and Change 2?

Mr. Guild: The witness identified that already.

A. The answer is still yes.

Q. 423. Plaintiff's Exhibit 5, Schematic Diagram of DDAC-2 Radio Receiver? A. Yes.

Q. 424. Plaintiff's Exhibit 6-A, Schematic Diagram of DDAC-3 Radio Receiver, marked at the lower left hand corner: "Issue 1?" A. Yes.

Q. 425. Plaintiff's Exhibit 6-B, Schematic Diagram of DDAC-3 Radio Receiver, bearing at the lower left hand corner the words "Issue 2?" A. Yes.

Q. 426. Plaintiff's Exhibit 7, Schematic Diagram—DDAC-4 Radio Receiver? A. Yes.

Q. 427. Plaintiff's Exhibit 8-A, DDAC-5 Schematic Diagram for the 7-A Radio Receiver? A. Yes.

Q. 428. Plaintiff's Exhibit 8-B, DDAC-5 Schematic Diagram for the 7-A Radio Receiver, marked "Issue 2?" A. Yes.

Q. 429. Plaintiff's Exhibit 8-C, DDAC-5 Schematic Dia-

gram for the 7-A Radio Receiver, also marked "Issue 2?"  
A. Yes.

Q. 430. Plaintiff's Exhibit 4B-1, Schematic Diagram of DDAC-1 Radio Receiver Jan. 13, 1926? A. Yes. May I ask you a question?

Mr. Philbin: Yes.

The Witness: This "yes or no;" should that be based on some specific thing that definitely ties my recollection to these particular sheets of paper, or should it be something based on my memory knowing what we did.

Mr. Philbin: Your answer should be based upon all your knowledge concerning the exhibits, that is, whether or not at the present time you can identify each of these exhibits as papers that you saw in 1925, 1926 or 1927, that is, on or about the dates that they bear.

The Witness: Thank you.

Q. 431. In the light of that statement, would your answer be the same as the answers you have given to the prior questions regarding the other exhibits? A. Yes, it would.

Q. 432. Plaintiff's Exhibit 5-1, Schematic Diagram of DDAC-2 Radio Receiver, marked "Issue 3?" A. Yes.

Q. 433. Plaintiff's Exhibit 4-E-A, Schematic Diagram for DDAC-1 Radio Receiver, Circuit Revision of Feb. 26, 1926, with three changes noted at the upper left hand corner? A. Yes.

Q. 434. Plaintiff's Exhibit 6-B-A, Schematic Diagram of DDAC-3 Radio Receiver, with "Issue 3" marked at the lower left hand corner? A. Yes.

Q. 435. Plaintiff's Exhibit 7-A, Schematic Diagram—  
DDAC-4 Radio Receiver? A. Yes.

Q. 436. Plaintiff's Exhibit 12 entitled: "Modified by P. H. Betts on or about Dec. 15, 1925, W & U H. F. Scarr



1/14/26." Superseded Jan. 4, 1926? A. Yes.

Q. 437. Plaintiff's Exhibit 13: "Tentative Current Sheet per Circuit as of December 15, 1925, DDAC-1 Radio Receiver? A. Yes.

Q. 438. Plaintiff's Exhibit 14, Modification of Dec. 30, 1925 Circuit, P. H. Betts, Jan. 4, 1926. Superseded Jan. 13, 1926? A. Yes.

Q. 439. Plaintiff's Exhibit 15, Direct Current Diagram per Jan. 4, 1926 Circuit, DDAC-1 Radio Receiver? A. Yes.

Q. 440. You have stated that the first of these DDAC sets was constructed and operated some time prior to December 30, 1925. Were any sets constructed and operated in accordance with the later DDAC-1 circuits, as shown in these exhibits? A. Yes, in the sense that certain of these circuit revisions shown in later sketches were changes made on what was the original model of these sets.

Q. 441. That is, from time to time the models would be modified in accordance with the revised circuit diagrams? A. Yes, that is correct.

Q. 442. Were the different sets or modifications of the sets operated from time to time? A. Yes.

Q. 443. At that time were you acquainted with the operation of other broadcast receivers? A. Yes.

Q. 444. How did the operation of these DDAC sets compare in performance with the other broadcast receivers then known to you, and by performance I mean the qualities of sensitivity, selectivity and fidelity? A. These models were much superior.

Q. 445. What other broadcast receivers were you acquainted with at that time, meaning 1925 and 1926? A. Well, there was Crosley, Freed-Eismann, Grebe, RCA. That is about all I can think of at the moment.

Q. 446. When these sets were operated in 1926 and 1927 with automatic volume control, as shown in the circuit diagrams, was their performance satisfactory? A. Yes, it was.

Q. 447. Were any of these sets operated during that time with the automatic volume control made inoperative? A. Yes, certain of the earlier models were provided with a key to switch from manual to automatic volume control.

Q. 448. Did you compare the operation with and without automatic volume control? A. Yes.

Q. 449. Was there any difference? A. Yes.

Q. 450. What was the difference? A. When using manual volume control the output varied widely as the incoming signal faded, while when the automatic volume control was used the output remained substantially constant for wide variations in the input.

Q. 451. How many of the 7-A type of receivers were constructed? A. Of the 7-A only two models were constructed.

Q. 452. Do you know what became of them or either of them? A. Yes. One model is still retained by Mrs. E. B. Craft, the other model is now with the Patent Department at 250 Hudson Street.

Q. 453. New York City? A. Yes.

Q. 454. Where did that model come from? A. Prior to sending it to the Patent Department I had it at my home for a period of about two years. Prior to that time it had been in storage and before it was in storage it had been used by Mr. J. J. Lyng, until the time of his death.

Q. 455. Where was it in storage? A. In the storage room of the Bell Laboratories at 463 West Street.

Q. 456. Did this 7-A receiver operate satisfactorily while you had it in your home? A. Yes, in a very satisfactory manner.

Mr. Philbin: Direct examination closed.

UNITED STATES DISTRICT COURT,  
DISTRICT OF DELAWARE.

24th floor, 20 Exchange Place,  
New York City,

February 19, 1935.

DEPOSITION OF EDWARD LOSEY NELSON, held on Tuesday,  
February 19, 1935, at 11 o'clock A. M. before Elizabeth  
Pritzker, a Notary Public.

APPEARANCES:

STEPHEN H. PHILBIN, Esq.,  
J. G. NORTON, Esq.,  
Counsel for Plaintiff,

BALDWIN GUILD, Esq.,  
Counsel for Defendant,  
MR. LANGLEY.

EDWARD LOSEY NELSON, being first duly sworn, testified  
as follows:

Mr. Guild: Before this witness starts his testimony, Mr. Philbin, have you yet put on the record the answer to Q. 377 of Mr. Betts' testimony, page 116.

Mr. Philbin: That question was an inquiry with respect to the value in ohms of various resistances, or resistors, used in the circuits of various exhibits. We have not yet obtained all those val-



ues, but we expect to have them and to supply them to defendant's counsel, as well as putting them in the record, in the next few days.

Mr. Guild: At this time we desire formally to enter on the record an objection to Plaintiff's Exhibit 3-C, on the ground that it is incompetent, and to all of the testimony heretofore given with respect to that exhibit, on the ground that it is irrelevant.

*Direct examination by Mr. Philbin:*

Q. 457. Please state your name, residence and occupation. My name is Edward L. Nelson. I live in Mountain Lakes, New Jersey. I am employed by Bell Telephone Laboratories as a radio engineer.

Q. 458. How long have you been connected with the Bell Telephone Laboratories? A. Since February, 1917, with the exception of a period of about 18 months during the War, during which I served in the Navy.

Q. 459. What was your position with the Bell Telephone Laboratories during the years 1925 and 1926? A. I was responsible for the development of the circuits employed in commercial radio apparatus.

Q. 460. What were your duties in connection with that responsibility? A. My duties were of a general supervisory nature and related to all classes of radio apparatus handled by the department, which included both transmitting equipment and receiving equipment.

Q. 461. Do you recall the so-called DDAC receivers developed and constructed by the Bell Telephone Laboratories? A. Yes, they were projects which were undertaken in the department, and I was responsible in a general way for the development of the circuits used in them.

Q. 462. I show you a carbon copy, dated November 25, 1925, entitled: "Intermediate Frequency Transformers

and Filters—Case 33079” addressed to Mr. W. Fondiller and signed O. M. Glunt, bearing the initials S. E. A. and E. L. N., referring among other things to the furnishing of transformers “for use in connection with our experiments on an automatic amplification control for this receiver.” Can you identify that paper? A. Yes. This is our departmental file copy of a memorandum written to Mr. Fondiller, requesting him to proceed with design work on transformers for this receiver.

Q. 463. Did you write your initials on that piece of paper? A. I did.

Q. 464. When? A. Between November 25th and December 2nd, 1925.

Q. 465. Was the material which is now on the paper in the form of typewritten matter, on it when you put your initials on the paper? A. Yes.

Q. 466. What does “case 33079” refer to or mean? A. This is a job number, which identifies the project, the authorization for it, and the file in which the papers associated with it, are kept.

Q. 467. What did you understand at that time to be meant by “automatic amplification control,” as stated in this paper? A. We had in mind that the receiver should have incorporated in it facilities whereby the audio frequency output would be maintained substantially constant by biasing one or more of the amplifier tubes with a voltage derived from and proportional to the receiver carrier.

Q. 468. I observe on this paper some letters written over the typewritten “O. M. Glunt.” What are those letters? A. They are the initials N. H. S. M. K., indicating that the original was actually signed by Mr. N. H. Slaughter. The initials M. K. are those of his secretary.

Mr. Philbin: Plaintiff offers in evidence the paper referred to as Plaintiff's Exhibit 16.

(Carbon copy of paper dated November 25, 1925 entitled "Intermediate Frequency Transformers and Filters—Case 33079" received in evidence and marked Plaintiff's Exhibit 16.)

Q. 469. I now show you two sheets of paper which are carbon copies, the first being dated January 22, 1926, entitled: "Special Intermediate Frequency Transformer for improved double detection radio receiver—case 33079" addressed to Mr. W. Fondiller, and having at the bottom of the second page, O. M. Glunt, and the initials S. E. A. and E. L. N. Can you identify those papers? A. These are the departmental file copies of a memorandum written to Mr. Fondiller, authorizing him to do further work on the coils required for the receiver.

Q. 470. Did you sign your initials, as indicated on this paper? A. I did.

Q. 471. When? A. Between January 22nd and January 25th, 1926.

Q. 472. Was the typewritten matter which is now on these sheets there at the time that you put your signature on it? A. It was.

Mr. Philbin: Plaintiff offers these two sheets as Plaintiff's Exhibit 17.

(Two sheets of paper, being carbon copies, the first sheet dated January 22, 1926, entitled: "Special Intermediate Frequency Transformer for improved double detection radio receiver—case 33079," received in evidence and marked Plaintiff's Exhibit 17.)

Q. 473. Plaintiff's Exhibit 17 refers in the first paragraph to "the automatic amplification control which is to be employed in the laboratory model of the improved double detection radio receiver" and also in the second paragraph to the "automatic amplification control." What



did you then understand that expression to refer to? A. To facilities for maintaining the output volume substantially constant by applying a bias to the amplifier tubes derived from and proportional to the received carrier.

Q. 474. I show you a simplified circuit diagram, Plaintiff's Exhibit 10, entitled: "A. V. C. System of DDAC and 7-A Receivers." Is that the kind of amplification gain control which you then understood was meant by that expression in Plaintiff's Exhibits 16 and 17?

Mr. Guild: The question is objected to. The witness has not stated that he understood any automatic gain control system.

Mr. Philbin: Answer the question.

A. Yes, this is the type of arrangement that was meant by the expression contained in the letter.

Mr. Guild: The answer is now objected to as hearsay.

Q. 475. What familiarity, if any, did you have with the development and construction of these DDAC receivers, including the feature of automatic gain control, or, as it is sometimes termed, automatic volume control? A. As I have already indicated, this work was conducted under my supervision. It was my duty to be familiar in a general way with the type of circuits that were being tried. The requirements which the apparatus was expected to meet were set up under my direction and I received regular reports as to the progress which was being achieved. It was also my duty from time to time to visit the laboratory in which the work was being conducted, to confer with the engineers actively engaged in the project, and to observe the results which they were obtaining.

Q. 476. Did you perform these duties? A. I did, to the best of my ability.

Q. 477. Where was the laboratory in which this work was being done? A. At 463 West Street.

Q. 478. Was your office in the laboratory? A. No. It was in an adjoining room, however, on the same floor.

Q. 479. Can you give us an idea as to how often you went into the laboratory and saw these receivers being developed, constructed or operated, that is, would it be once a month or once a week, or two or three times a week? A. I was probably in the laboratory several times a day, but of course did not always discuss the matter with the engineers engaged on this particular project, because there were other activities under way at the same time.

Q. 480. Did you ever discuss the feature of automatic amplification control with the engineers as they were developing or constructing the DDAC receivers? A. This feature could hardly have been incorporated in the set without my concurrence.

Q. 481. Did you concur? A. I did, or it would not have been there.

Q. 482. I show you Plaintiff's Exhibit 1-A, which has your initials at its end. Can you identify those initials? A. Yes, these are my initials.

Q. 438. Can you tell us when you put those initials on that paper?

Mr. Guild: The witness has not stated that he put his initials on the paper.

Mr. Philbin: I withdraw that question.

Q. 484. Will you tell us whether or not you put those initials on that paper? A. I did.

Q. 485. About when? A. Shortly after the date of the memorandum, that is, September 14th, 1925.

Q. 486. Will you state whether or not the typewritten matter above your initials was there at the time you put your initials on that paper? A. It was.

Q. 487. Did you ever hear any of these DDAC receivers being operated to receive either broadcast signals or signals generated in the laboratory? A. We made occasional tests in which regular broadcast signals were received, and I participated in a number of such tests.

Q. 488. Were all those tests conducted in the laboratory? A. No, I recall one occasion in which we transported the set to the Pocono Manor Inn in Pennsylvania, and conducted a test at that point.

Q. 489. Do you recall any of the persons that you refer to as "we", who were present at that operation at the Pocono Manor Inn? A. The party who went to Pocono Manor Inn on the occasion to which I refer consisted, I believe, of Messrs. Slaughter, Evans, Anderson, Betts and myself.

Q. 490. About when was this trip made? A. Early in the Spring of 1926. I believe it was in April.

Q. 491. Do you recall why you went to Pocono Manor Inn? A. It is my recollection that Mr. Slaughter, Mr. Evans and myself went there on the Lackawanna Railroad.

Q. 492. Why did you go to Pocono Manor Inn instead of some other place? A. Our objective in constructing this receiver was to produce a model which would incorporate all the features that we considered desirable in a receiver for broadcast reception. It was attempted to incorporate in it maximum sensitivity, high fidelity, all the gain that could be used under any practical condition, automatic volume control, and ease of operation. The purpose of going to the Poconos was to be able to test at a point remote from the city, where we had reason to believe that the noise level would be relatively low, so that we could make an attempt to receive signals from stations at great distances, in order to determine the performance of the receiver under such conditions.



Q. 493. Was the set operated on the occasion of this trip to Pocono Manor Inn, to receive broadcast signals?

A. Yes, it was operated after dinner and until an early hour the following morning.

Q. 494. Were any broadcast signals received? A. We received a considerable number of stations. Results on distant stations were somewhat disappointing because of interference produced by the local lighting plant. A number of stations located at considerable distances were received, however. The only ones which I remember at the present time were a Canadian station and WBAL in Baltimore.

Q. 495. Was the set operated both with the automatic volume control effective, and without the automatic volume control being effective? A. Yes, the receiver used for this test was equipped with a switch which enabled the automatic volume control to be cut in or to be cut out at will.

Q. 496. Was any audible difference observed by you when the receiver was operated without automatic volume control, as contrasted with the operation with automatic volume control? A. Yes, observations were made with a loud speaker, and on WBAL in particular marked fading was experienced when the automatic volume control was not in use.

Q. 497. Was any fading observable when the automatic volume control was used in receiving the signals from that station? A. With the automatic volume control in use the volume was substantially constant. This particular test made considerable impression upon me because it was the most conclusive demonstration that I had observed up to that time of the advantages of automatic volume control. It was my conclusion that at this point the signals from WBAL without automatic volume control would have had absolutely no entertainment value,

whereas when automatic volume control was used the program was a reasonably satisfactory one to listen to.

Mr. Guild: The latter part of that answer concerning the witness's conclusion is objected to as volunteered.

Q. 498. Did you observe the differences with respect to use and non-use of automatic volume control in any way other than by listening to the differences? A. The receiver was equipped with a meter in the output circuit of the volume control rectifier, which indicated the rectified carrier component at this point in the circuit.

Q. 499. Did this indicator indicate to you the difference between use and non-use of automatic volume control, and if so, how? A. Yes. When the receiver was used with the automatic volume control cut out, and was tuned to a distant station, such as WBAL, the deflection of this meter varied over a wide range, indicating corresponding variations in the input signal due to fading. With the switch in the automatic volume control position, the variation and deflection of this meter was very materially reduced, and it maintained a substantially constant deflection.

Q. 500. What do you mean by fading? A. Fading has been used in this testimony in two connections, first with respect to variations in the intensity of the received radio frequency signals due to variations in transmission, and second with respect to corresponding variations in the audio output of the receiver, resulting from such variations in received signals.

Q. 501. Will you state whether or not you were familiar in 1926 with any broadcast receivers other than the DDAC receivers? A. I had had occasion to observe a number of the commercial receivers then on the market, in the laboratory, in my own home, and in the homes of my friends.

Q. 502. What were the names of some of those receivers? A. Fada, RCA, Grebe, Freshman and Atwater-Kent.

Q. 503. How did the operation or performance of the DDAC receivers compare with the commercial broadcast receivers on the market in 1926, such as those you have mentioned, with respect to sensitivity, selectivity and fidelity?

Mr. Guild: The question is objected to because it refers to "DDAC receivers" in the plural, and vaguely connects such receivers with the specific receiver the witness referred to last. This witness, so far as I recall, has not testified about the operation of any receiver other than that tested in Pocono Manor Inn.

The Witness: Will you read the question, please?

(Question repeated by the stenographer.)

Mr. Philbin: I will add for possible clarity that the expression "DDAC receivers" in the question was intended to mean receivers of the DDAC type such as the DDAC receiver operated at Pocono Manor Inn.

Mr. Guild: The witness has not referred to any receivers, other than that receiver referred to in connection with the Pocono Manor Inn, as being typical of any group.

Mr. Philbin: Question withdrawn.

Q. 504. Did you witness the operation of any DDAC receiver other than the one that was operated in Pocono Manor Inn? A. I assume that the significance of these series of DDAC numbers has been indicated elsewhere in the testimony. As I recall, these numbers were not intended to indicate that the development consisted of a



series of more or less distinct steps, at each of which a number of models of a given type were produced. The work was a development enterprise and in many of the later steps the same model was modified from time to time as the work progressed and carried in succession one number after another. The different designations were applied from time to time as the changes became of such importance that a new circuit drawing was needed. I undoubtedly heard tests on many of these different versions, but am unable at this time to fix definite dates, and would not even care to testify as to the exact number of the model which was employed at Pocono Manor.

Q. 505. Have you ever heard of a receiver known as the 7-A receiver? A. Yes.

Q. 506. What was that? A. When our laboratory work, our preliminary work, was substantially completed, we then undertook to prepare a finished model which was carefully constructed in the shop, with the thought that it would serve to indicate to our executives the form which this type of receiver might take if it were decided to offer it for sale. This model (two were made) was known as the 7-A receiver.

Q. 507. What relation, if any, was there between the 7-A receivers and the DDAC receivers? A. The DDAC receivers were preliminary models undertaken during the course of the circuit development. When the circuit was finally crystallized the arrangement decided upon as having all the desirable characteristics which we had sought was incorporated in this finished model, which was designated 7-A.

Q. 508. How did the set that was operated at Pocono Manor Inn compare, with respect to sensitivity, selectivity and fidelity, in relation to the other 1926 broadcast receivers that you have mentioned? A. It was more sensitive, more selective and gave much better fidelity than the commercial receivers of the time.

Q. 509. Can you state whether or not the same was true of the other operations of the DDAC receivers and 7-A receivers, with which you were familiar?

The Witness: Will you read that question, please?

(Question repeated by the stenographer).

A. The tests of these receivers which I witnessed indicated that its performance was outstanding in these respects.

Mr. Philbin: Direct examination closed.

I suppose you want your usual time to consider what, if any, cross-examination you desire.

Mr. Guild: Yes, we should like to continue as before.

(Deposition adjourned without definite date.)

Adjourned examination held on Wednesday, April 24, 1935, at 11 o'clock A. M.

APPEARANCES:

For plaintiff:

Stephen H. Philbin, Esq.,

J. G. Norton, Esq.;

For defendant:

William H. Davis, Esq.,

Baldwin Guild, Esq.,

Mr. Langley.

EDWARD L. NELSON, resumed the stand and further testified as follows:

*Cross-examination by Mr. Davis:*

Q. 510. Will you look, Mr. Nelson, at this letter, which is Exhibit 17, to Fondiller from Glunt, and first tell me do you know why the date was changed from January 22nd to January 25th? I call your attention also to Exhibit 16, in which the date was changed from November 25th to December 2nd. Can you explain those?

A. You are inviting attention to a matter of office routine, which will be observed with great frequency in connection with our inter-departmental correspondence. In a relatively large organization, where a number of approvals are required before the final signature is affixed to a piece of correspondence, some time generally elapses between the date on which the letter is dictated and the time when it is finally signed. Our customary procedure is to require the dictating stenographer when she writes the material up from her notes to affix the date and later it is changed to indicate when the final signature has been affixed.

Q. 511. Then it is indicated with respect to Exhibit 16 that the dictation is on November 25th and it was signed on December 2nd, is that right? A. That is correct.

Q. 512. And Exhibit 17, it is indicated, was dictated on January 22nd and signed on January 25th? A. That is also true.

Q. 513. Who was Mr. Fondiller, what was his job? A. Mr. Fondiller had charge of the group which was responsible for the design of transformers, condensers, retardation coils, etc.

Q. 514. And who was Mr. Glunt? A. Mr. Glunt was in charge of the Special Products Department, which included the radio group in which myself, Mr. Anderson, Mr. Betts, Mr. Scarr and Mr. Fischer were located.

Q. 515. In Exhibit 16 Mr. Glunt asked Mr. Fondiller to supply two additional W6417 input transformers for use in connection with their experiments on automatic



amplification control for the receiver. Do you know whether those transformers were supplied and whether they were used in the experiments? A. I believe that they were.

Q. 516. Do you know whether the W6417 transformers were the devices that are referred to in Exhibit 17 as "a special coil furnished by your Department as a coupling transformer between the amplifier and the control rectifier"? A. I don't think that is the particular transformer referred to in the latter case.

Q. 517. You think the transformers W6417 referred to in Exhibit 16 were not used as the coupling transformer between the amplifier and the control rectifier? A. My familiarity with these code numbers, Mr. Davis, is not very great. From some of the circuit schematics which are in evidence, and which I have reviewed recently, it appears that W6417 was used as the interstage transformer in the intermediate frequency amplifier. I am unable to state, therefore, of my knowledge, why this last sentence was phrased in the words which were used. I assume that any information which may be required on that point can be or has already been obtained from the men who were in more detailed contact with the work than I was.

Q. 518. Well, then, you don't know yourself what type of transformer it was that was referred to in Exhibit 17 as "the special coil furnished by your Department as a coupling transformer between the amplifier and the control rectifier"? A. No.

Q. 519. Am I correct in understanding that the "special intermediate frequency transformer for use in connection with the automatic amplification control" referred to in Exhibit 17 as something which the engineers desired, was desired because the "special coil" previously used developed a resonance peak of approximately 1.5

at about 92 kilocycles? A. As far as I am concerned, the statements in the letter will have to speak for themselves. I believe them to be true.

Q. 520. And that is your interpretation of the letter, is it? A. Yes.

Q. 521. Do you know why it was that at this time it was desired to have a special intermediate frequency transformer of a more sharply selective character than the one that had previously been used? A. Well, in general I believe that it is desirable for a coil to be used in this manner to be as sharply selective as it can be made consistent with reasonable cost of manufacture. I believe that this was the principal objective which we had in mind in ordering the new transformer, in addition, of course, to correcting this deficiency represented by the resonant peak at 92 kilocycles.

Q. 522. That is, as I understand it, this intermediate frequency transformer was desired to be sharply selective to the carrier frequency, and that is expressed more in detail by the paragraphs numbered 3 and 4 at the bottom of the first page of Exhibit 17, is that right? A. That is true.

Q. 523. That is, the purpose was to select the carrier frequency from the intermediate frequency amplifier system and transmit that through this special transformer to the rectifier tube used in the automatic volume control? A. Yes.

Q. 524. Now, will you look at Exhibit 1-A, which you testified that you initialed, and which is dated 9/14/25. As I understand it, your initialing of the memorandum was your approval of the work set forth in the memorandum, is that right? A. Yes, but not entirely in that sense. It is an approval, but it is our custom in connection with memoranda for file, for obvious reasons, to permit the

engineers a great deal of freedom of expression in these purely record statements. Had there been anything which I felt was contrary to fact, or seriously objectionable for other reasons, I would have discussed the matter with the writer and agreed with him on a corrected form. The initials do indicate that I agreed with the sense of the document or of the letter, and of course that I had seen it; that is the important factor. I had read it.

Q. 525. No mention is made in Exhibit 1-A of the automatic amplification control, and so far as your direct examination showed, the first document initialed by you that refers to any experiments on automatic amplification control was the document sent December 2, 1925, Exhibit 16. Have you any recollection of any intermediate document that had your approval and that mentioned experiments with automatic amplification control for these receivers? A. I don't recall when a definite decision was first reached to incorporate automatic amplification control in this receiver, and I don't recall of any earlier document which makes our decision a matter of record. The matter was under consideration, however, for quite a little time, as is usual in most cases before we definitely decided to incorporate them.

Q. 526. Well, will you look, Mr. Nelson, at Exhibit 10, which on direct examination you said was a diagram illustrating the kind of amplification or gain control which you then understood was meant by that expression in Plaintiff's Exhibit 16 and 17, and identify for us on Exhibit 10 the connection which is referred to in Exhibit 17 in the following words: "We have found that the grid circuit of the amplifying tube for the automatic amplification control may be connected to one of the primary windings of the final filter coil in the intermediate frequency amplifier." A. Will you read the question?



(Question repeated by the stenographer.)

The Witness: The winding referred to is L8 and it will be noted that the upper end of this winding leads to the grid of the tube marked "IF Amplifier" in the combination at the bottom of the page which represents the automatic volume control facility.

Q. 527. And that tube marked "IF Amplifier" is the "amplifying tube for the automatic amplification control" referred to in Exhibit 17? A. That is true.

Q. 528. Now will you identify in Exhibit 10 the place at which the new desired special intermediate frequency transformer was to be used? A. This is the transformer shown near the bottom of the page between the IF amplifier tube just mentioned and the tube marked "AVC Rectifier".

Q. 529. Exhibit 17 specifies that this transformer shall be so designed that "the voltage amplification at 82 and 84 kilocycles should be less than at 83 kilocycles". Does that mean that the intermediate frequency was 83 kilocycles? A. Yes.

Q. 530. It is true, is it not, Mr. Nelson, that a low intermediate frequency such as 83 kilocycles makes it easier to separate the carrier from the side bands than if the intermediate frequency were higher? A. Yes.

Q. 531. So that this receiver was designed with a low intermediate frequency, making it easier to separate the carrier from the side bands and the transformer which selected the carrier frequency and passed it on to the AVC rectifier was designed to sharply select that chosen carrier frequency, is that a correct statement? A. Well, I don't believe that we were principally concerned with this matter of selecting between carrier side bands when this 83 kilocycle frequency was selected. As a matter of

fact, it was higher than the intermediate frequency which we had been using previous to that time in our commercial superheterodyne receivers. I believe that considerations of amplification and of coil design had more to do with the choice of this particular value than the question of selectivity which you mentioned.

Mr. Davis: Will you read my question?

(Question repeated by the stenographer.)

Mr. Davis: You see, Mr. Nelson, your answer did not quite answer my question. You entered into a discussion of the purpose of the choice of the 83 kilocycles. My question is a little different from that. Will you answer it the way I asked it?

The Witness: Will you read the question please?

(Discussion off the record.)

(Question repeated by the stenographer for the witness.)

The Witness: It is true that this transformer was designed to select the carrier component and discriminate against the side bands.

Q. 532. You testified, Mr. Nelson, about the operation of one of these embodiments of these new double frequency receivers with automatic volume control, during the development period at Pocono Manor Inn. Can you identify for us the circuit diagram as it existed in the receiver that was used at Pocono Manor Inn? A. I can't say of my own knowledge, Mr. Davis, which particular version of this receiver was tested at Pocono Manor Inn.

Q. 533. Who would know, do you know, Mr. Nelson? A. Mr. Betts, probably.

Q. 534. You testified that Mr. Slaughter and Mr. Evans were there at the tests, as you recalled. Would either one of those men know what the circuit arrangement



was? A. They might, but I doubt it for the reason that Mr. Slaughter, of course, as my superior was one degree further removed from the job than I was, and Mr. Evans was there not as a man directly connected with the project, but as one who had charge of a certain phase of our broadcasting work and therefore whose opinion as to the performance we valued and were desirous of obtaining.

Q. 535. That was Porter H. Evans? A. That is true.

Q. 536. Was he a Western Electric engineer or a Bell Telephone Laboratories engineer? A. Bell Laboratories.

Q. 537. Who was Harald T. Friis? A. A radio engineer in the Research Department of Bell Laboratories.

Q. 538. Have you no clear recollection now, Mr. Nelson, of the performance, I mean in detail, of the receiver at Pocono Manor Inn, early in the Spring of 1926, about which you testified? A. Detail is a somewhat relative term. Do you mean in more detail than my testimony as already covered, or what is the meaning?

Q. 539. Well, I had two thoughts in mind in my question, Mr. Nelson. I want to arouse your recollection of the thing, you see, rather than your reasoning about it, and also I noted in your testimony that you spoke of the behavior of the set when it was tuned in to a particular station, and you testified that you observed the reduction of the effect of fading when the automatic volume control was cut in. I wondered if you had any further recollection of what was done in that light, and whether you tuned in different stations, and what the general performance of the thing was. A. Well, the receiver, as I recall, was set up on the floor below the lobby in the hotel and after dinner the party gathered in this room, which was detached from the sleeping quarters of the hotel so that we could operate the loud speaker as we pleased, and for a number of hours we listened to what-



ever stations we could tune in. As I testified previously, I don't recall many of the stations that we heard. I believe there was one Canadian station, it may have been Montreal, it may have been Toronto, I am not sure, but the incident which made the greatest impression upon me was our experience with WBAL, which I previously referred to. On that station marked fading was observed without the automatic control, but with the control in use the signals were quite constant, and in my opinion had considerable entertainment value, which was not the case without the control. As I indicated previously, this made a particular impression on me because up to that time it was the outstanding demonstration that I had had of the utility of such a device. You might say that from then on I was thoroughly sold on the merits of automatic volume control.

Q. 540. I understand that this receiver had 12 or 13 tubes, didn't it? A. Of that order, yes; too many.

Q. 541. Well, you mean it was too elaborate a thing for general purposes? A. Well, that was one of the reasons why I believe it was never launched commercially on the market.

Q. 542. Well, do you think it is quite fair, Mr. Nelson, to compare it as you do with the Fada, RCA, Grebe, Freshman and Atwater-Kent receivers that were then on the market? A. Well, I don't know the purpose of that comparison, and as I recall I did not draw a very sharp comparison. They were simply mentioned as receivers of the period. They of course were much less elaborate and gave a much inferior performance, but they were the commercial receivers of the time.

Q. 543. But they were not comparable, either in the manner of elaboration of design or number of tubes or cost of production, were they? A. No.

*Re-direct examination by Mr. Philbin:*

Q. 544. You spoke of your commercial superheterodynes. What was the frequency of the intermediate frequency in those sets that you referred to? A. Approximately 50 kilocycles.

Q. 545. Were those broadcast receivers? A. Yes.

Q. 546. That is, they were adapted to receive stations operating within the broadcast range? A. That is correct.

Q. 547. You stated on cross-examination that some time during the Pocono operation "you were thoroughly sold on the merits of automatic volume control". Can you tell us whether you were referring to the merits of automatic volume control as a technical matter, or as used in this set, or in what sense you used that expression? A. I was satisfied that it was a feature which was useful and desirable for radio receiving sets for broadcast reception in the home.

Redirect examination closed.

Examination adjourned without date.

ADJOURNED EXAMINATION held on the 12th floor of 711 Fifth Avenue, Borough of Manhattan, New York City, on Thursday, May 2, 1935, at 10 o'clock A. M.

APPEARANCES:

For plaintiff:

Stephen H. Philbin, Esq.,

J. G. Norton, Esq.;

For defendant:

Baldwin Guild, Esq.,

Mr. Harold A. Wheeler.

HENRY F. SCARB, being first duly sworn, testified as follows:



*Direct examination by Mr. Philbin:*

Q. 548. What is your residence and occupation, Mr. Scarr? A. My residence is 15 Reading Terrace, in Fairlawn, New Jersey, and my occupation is sales engineer.

Q. 549. With what concern are you connected now? A. Western Electric Company, Incorporated.

Q. 550. With what concern were you connected in 1924 and 1925? A. Bell Telephone Laboratories, Incorporated.

Q. 551. What was your position then with the Bell Company? A. Radio engineer.

Q. 552. Where were you located? A. At 463 West Street.

Q. 553. New York City? A. New York City.

Q. 554. State generally what your activities were as radio engineer with the Bell Company. A. I was engaged in developing radio receiving sets.

Q. 555. Did you have anything to do with some of the receivers that were known as the DDAC or 7A receivers? A. Yes, I did.

Q. 556. What did you have to do with them? A. Why, I performed numerous tests on circuit designs for them and was generally associated with the other members of my group who were doing the design work for this set.

Q. 557. Do you recall when you commenced working on this set? A. It was in the Fall of 1925. I don't remember the exact date, but it was somewhere around November, I should say.

Q. 558. Did you make any notes of your work in 1925 in connection with these sets? A. Yes, I did. I had a laboratory book in which such notes were made.

Q. 559. I show you a notebook which has on the inner cover "H. F. Scarr, Dept. 311 B-1-C", page 1 of which is dated June 18, 1925 marked "Double Detection Rec. Osc. Design", and the outside cover is marked "311-B-



49". Is that the notebook to which you referred? A. That is the notebook, yes.

Q. 560. What does the 311-B 49 mean? A. The 311-B is the department number in which I was engaged, and the 49 is the laboratory book number.

Q. 561. Did you write the words "H. F. Scarr, Dept. 311 B-1-C"? A. I did.

Q. 562. When? A. On or before the first entry in the book, which is June 18, 1925.

Q. 563. Can you tell us which, if any, of the entries in this book, commencing on page 1 and continuing, were made by you in your handwriting on or about the dates shown on the respective pages? A. Beginning with the June 18th entry over to page 99 all the pages in between are in my writing. Page 100 to 103 are in the writing of others. 104 is in my writing. 105, 106, 107 (going through pages), 108, 109, 110, 111, over to 123, including 123.

Q. 564. I notice various curve sheets attached to some of the pages to which you have referred as having entries made by you. Were such curve sheets also made by you? A. Yes, they were.

Q. 565. And on or about the dates of the pages to which they are connected? A. Yes, sir. I have to revise my previous testimony about when I started work on the set, because the first entry in the book having to do with that set was the June 18th entry, so I must have started working on it about that time.

Q. 566. That is, on or before June 18, 1925? A. Yes, sir.

Q. 567. Do these curve sheets show in graphic form measurements and the data which also appear in the pages to which the curve sheets are connected or in immediately adjoining pages? A. They do.

Q. 568. Now will you tell us what work you did on or

about June 18, 1925 in connection with this "Double Detection Receiver"? A. This particular entry has to do with an investigation of the radio frequency oscillator design, otherwise known as the frequency changer circuit.

Q. 569. Do you recall whether or not there was any automatic gain control used at any time with these receivers?

Mr. Guild: The question is objected to as leading.

The Witness: Shall I answer that?

Mr. Philbin: Yes.

A. Yes, there was automatic gain control used in connection with these sets.

Q. 570. When did you first discuss automatic gain control in connection with this double detection receiver, approximately?

Mr. Guild: The witness has not testified that he discussed any of this work.

Mr. Philbin: I withdraw the question.

Q. 571. Did you ever discuss automatic gain control in connection with these receivers? A. I did.

Q. 572. When was the first time, approximately, that you discussed it with anyone? A. Well, I discussed it with Mr. Friis and also the other members of my department during the early stages of this development.

Q. 573. Who were some of those other members of your department? A. Mr. Anderson, Mr. Betts, Mr. Fischer.

Q. 574. Will you tell us when you first discussed automatic gain control with any of these people in connection with these receivers? A. Well, it was during the middle of the year 1925 and thereafter. I don't fix a definite date, but it was during the period which these tests covered and was certainly prior to the time we had as an



objective automatic gain control. It was prior to the time that we set up our circuits for controlling gain.

Q. 575. Now you have said that your entry under date of June 18, 1925 referred to some work of yours in connection with the radio frequency and oscillator parts of this double detection receiver. How long did you continue working on those parts, as evidenced by your notebook? A. Well, about the first of September we began an investigation of the intermediate frequency portion of the set.

Q. 576. 1925? A. 1925, so that prior to that time we had been working on the radio frequency end.

Q. 577. Did you do any work on any other part of the set than the radio frequency part, the oscillator part, and the intermediate frequency part? A. During that time we did quite a bit of construction work on the set. This notebook covers measurements and the September date is really the time we began to measure the intermediate frequency portion of the set. So that time between June and September was not taken up entirely with measurement of the radio frequency, but covered the time that we were building the circuits and preparing for further tests.

Q. 578. On page 31 under date of November 16, 1925, there is a page entitled "Intermediate freq. characteristic of lab. model number 1" with various figures, apparently denoting measurements, underneath. What does that page refer to? A. Well, that refers to an intermediate frequency characteristic test on the set, that is, a test of transmission through the intermediate frequency portion of the receiver, using a carrier of intermediate frequency to determine the width of the side bands which that portion of the set would allow to pass.

Q. 579. Why were you interested in ascertaining these facts? A. Well, it was our objective to design a very high



quality set, and of course the fidelity of the set, which was one of the features we wanted to make as good as possible, depended among other things on the intermediate frequency characteristic.

Q. 580. Can you state whether or not that entry had anything to do with automatic gain control? A. Not directly, no.

Q. 581. On page 34 under date of November 18th there is a page entitled "Int. freq. lab. model number 1 I<sub>2</sub> and I<sub>3</sub> cut out". What does that mean? A. Well, that's where we began our tests covering the method of controlling the gain of the receiver. I<sub>2</sub> refers to the intermediate frequency tube number 2 and I<sub>3</sub> refers to intermediate frequency tube, or stage number 3. It really is a complete stage, rather than the tube, including the circuits surrounding the tube and associated directly with it. On this particular test we determined what happened when we caused the second and third intermediate stages to cease to amplify.

Q. 582. How did you stop them from amplifying? A. By reducing their grid voltage, or rather increasing the negative voltage on their grids.

Q. 583. That is, you biased the grid of one tube and determined how much the gain would be reduced, and then you did the same thing with another tube, is that it? A. That is correct, yes. They were both cut out in that particular entry, yes.

Q. 584. At the same time? A. At the same time.

Q. 585. How much was the gain reduced when the grids of its intermediate frequency tubes were biased, as shown by your notes, approximately? A. Well, the notes don't cover that point, but we were not interested so much in how much the gain was reduced, but what reducing this gain did to the intermediate frequency characteristic, and that's what the data taken in this par-

ticular test was to prove, that when the gain was reduced very low on the second and third stages the intermediate frequency characteristic would be still of a desirable form.

Q. 586. What do you mean by desirable, fidelity? A. As regards fidelity, that's right.

Q. 587. That is, these measurements were to determine what would happen if you used automatic gain control, with respect to the fidelity characteristic? A. That's correct, yes.

Q. 588. And what conclusion was reached, as shown by these measurements? A. The measurements show that controlling the gain by increasing the bias on those tubes would still be quite satisfactory.

Q. 589. On page 36 of your notebook under date of November 23, 1925 there is a page on which appears only the following words, in addition to the date: "Amplification control by varying  $V_{I1}$  input at 83 kc." What is meant by those words? A. The  $V_{I1}$  refers to the bias voltage on the first intermediate frequency tube, and this entry had to do further with the investigation of the amplification control by varying the bias on that tube.

Q. 590. On page 37 there are some entries under the same date which apparently are the results of various measurements. What were those measurements? A. Those measurements were started, but they were stopped at that time because we found we needed to know a little more about some of the other circuits before we made that particular test, so that on the next two pages, under the same date, November 23rd, we took some more intermediate frequency characteristics. This particular one referred to the intermediate frequency characteristic when the bias on the first intermediate frequency tube was reduced to minus 30 volts, the amplification in that case was approximately one one-hundredth of full gain,



and the data, together with the data on the next two pages, 40 and 41, in which the bias was reduced to minus 30 volts on the second intermediate frequency stage, are plotted on the curve, also dated November 23, 1925, and show that the intermediate frequency characteristic was somewhat adversely affected when the bias was reduced on each of the individual tubes, but one tube was affected on one side and the other on the other side, so that they gave promise, when they were added together, of compensating one for the other, therefore resulting in an overall characteristic which is entirely satisfactory.

Q. 591. Then, as I understand it, on November 18, 1925 you commenced ascertaining what effect with respect to fidelity automatic gain control would have, first trying it on two tubes together and then trying it on each tube separately, is that right? A. That's correct, yes.

Q. 592. And then under date of November 23, 1925, with the curve sheet there, there is shown what happened to each of these two tubes with respect to fidelity, when their grids were respectively biased? A. That's correct, yes.

Q. 593. Page 42 of your notebook under date of November 24, 1925 has the words "Amplification v. s.—neg. grid volts on  $I_2$  at 84 kc. cut off  $I_2$  at minus 25 v.", with an accompanying curve sheet. What does that mean? A. Well, this curve sheet shows the plate currents of  $I_2$  plotted against the grid bias volts of the same tube, showing that cut-off did occur at or about minus 25 volts.

Q. 594. That is, when you put 25 volts in the grid of that tube it prevented operating? A. Ceased amplifying. However, this curve is preliminary information to show the cut off at that point, and then the test begun on November 24th showed the first part of this statement, the amplification plotted against the negative grid volts, which is this curve, also dated November 24th, showing



the gain at various values of grid bias on the second intermediate tube. This curve showed that we could control the gain from the cut-off to practically maximum gain by a variation from about minus 24 volts to about minus 14 volts, meaning that a variation of 10 or possibly 11 volts would change that tube from cut-off to this maximum amplification, or vice versa, depending on the direction of the change.

Q. 595. What kind of tubes were you using? A. Well, we were using for this portion of the set either 231Ds or 230 type tubes, Western Electric tubes.

Q. 596. What were the differences between these two types? A. Well, they were very, very similar. I don't remember the exact details now, but they were the same type of tube. They varied in minor details.

Q. 597. That is, their electrical characteristics were substantially the same? A. Substantially the same.

Q. 598. What was the normal plate voltage employed with those tubes in the intermediate frequency part of the set? A. I believe we used somewhere around 90 volts, although I think it was allowable to run that up to 120 or 130.

Q. 599. By "allowable" do you mean there was nothing critical about the plate voltage? A. Nothing critical about the plate voltage, that is, with the exception of when you are attempting to get cut-off or something along that line; as in all vacuum tubes, the characteristic of the tube depends on the voltages you use upon it, fixing one set of values, would fix other values, such as the grid voltages which it was necessary to use.

Q. 600. What does the entry on page 44 on November 23, 1925, with its accompanying measurements or results of measurements, on page 45, refer to? A. Well, this is a check of the data on the preceding two pages.

Q. 601. And pages 46 and 47? A. That again is an-

other check of the same data, using extreme care to obtain great accuracy in the measurement.

Q. 602. How do the checks correspond with the original measurements? A. They are not such as to change the conclusion. They show the same result.

Q. 603. What about pages 48 and 49, both under date of November 27, 1925? A. Well, in the preceding curves on the frequency characteristic which I referred to a moment ago as the curve dated November 23rd, we wanted to see what effect balancing would have on changing the peaks and valleys in that curve.

Q. 604. By "balancing" you mean balancing one tube against another? A. Yes, that's true. Well, really neutralizing, that's what is amounted to, with a small capacity condenser, but this particular data on 48 and 49 shows that it was impossible to prevent singing or oscillation of the first intermediate stage through the balancing condenser, so that we didn't take any test, after we found it out, on that particular setup.

Q. 605. What are the measurements on page 49? A. Those are not measurements. That was merely the form we set up to take measurements, before we found this singing condition.

Q. 606. On page 50 under date of November 28, 1925 there are the following words: "Ampl. vs. same-grid bias on  $I_1$  and  $I_2$ ". What do those words mean? A. Well, the first two tests on the intermediate frequency amplification, using the same grid bias on the first and second intermediate stage, it shows the effect on the gain, intermediate frequency gain, of the set by varying the voltage of those two tubes at once. This is an actual measurement of what we had tried before. It shows, incidentally, that varying the negative bias from approximately between 28 and 29 volts negative to somewhere between around 16 volts gives practically the complete range of gain which our amplifier would give us.



Q. 607. What apparatus did you use in making the measurements which resulted in these figures? A. Well, we used an oscillator generating a frequency of 83 kilocycles for our input circuit. We fed this into the modulator tube through an input box or a resistance box arranged, so that we could vary the amount of input, which also had a meter, a thermocouple meter connected in its circuit to measure the amount. The circuit was set up so we knew what voltage we were introducing to the amplifier, and then at the output of the amplifier we had a vacuum tube rectifier circuit, a vacuum tube volt meter circuit which was set up and calibrated to give us the relative output of the amplifier for different input values.

Q. 608. Well, as I understand it, you had some apparatus there that was receiving 83,000 cycles or how many kilocycles? A. 83 kilocycles.

Q. 609. And that was received first by a so-called modulated or first detector tube? A. Yes, that's the tube in the set.

Q. 610. That was the first tube in the receiving set which received the signal? A. Well, the first tube, the modulator tube, the first tube was really the radio frequency amplifier tube.

Q. 611. That is what I wanted to find out, exactly what the apparatus was that received this signal. A. We were feeding in this particular test into the intermediate amplifying system, of which the first tube was the modulator tube.

Q. 612. How many intermediate frequency tubes did you have? A. Three.

Q. 613. And what were the other tubes in the set? A. There was a radio frequency amplifier, an oscillator, a second detector. The modulator tube is really the first detector, that is another name for it, and then a fourth intermediate frequency amplifier which formed a part



of the automatic gain control circuit and the gain control rectifier. Those are the tubes around this portion of the circuit, then there were also tubes in the audio frequency end. There was a first audio amplifier, which is the same type of tube, then there were pushpull 205 type of tubes used for output, audio output, and then there were two rectifier tubes rectifying the alternating current power supply voltage to supply the set with power.

Q. 614. Were all these features operating when you made these measurements? A. Well, no. It was not necessary for them to operate. I don't recall whether they were or not. As a matter of fact, it was only necessary for this test that we were making to use part of the set.

Q. 515. What were the features that you do know were used in making these measurements? A. May I refer to one of these documents that you used previously, to point them out?

Q. 616. Yes. A. We were using a modulator tube, and the three intermediate frequency amplifier tubes and the second detector tube. That was the part of the set which was involved in this particular measurement.

Q. 617. Did you use any automatic gain control tubes in making these measurements, in addition? A. Incidentally, that same thing is shown on preceding circuits. I just happened to pick that 4A. It is shown also on Exhibit 2.

Q. 618. Now you say you used the modulator or first detector, the three intermediate frequency tubes and a second detector tube. Did you use any other tubes in making the measurements, the results of which are shown under date of November 28, 1925? A. Well, the other tubes were probably in the circuit, they were tied in with the power supply system. The power supply system depended upon their being in their sockets to maintain the

proper voltages throughout the system, but they didn't enter into the tests in any other way.

Q. 619. Did you use any automatic gain control tubes in these measurements? A. Not in those measurements, that is, except as in answer to the previous question.

Q. 620. On page 52 under date of 11/30/25 there is the statement "Int. freq. characteristic with  $-28$  v. on  $I_1$  and  $I_2$ ", together with a curve sheet on the same date, and some measurements on the same date, on the opposite page. What did you do there? A. That probably refers to the previous—that is carrying on that same intermediate frequency characteristic investigation. I am just trying to determine how it differed from those previous measurements. We used minus 30 before and here we use minus 28, that is about the only difference.

Q. 621. On page 54 under date of 12/2/25 there are the following words: "Int. freq. characteristic with automatic gain control hooked across 250 mmf. condenser in second filter, but not delivering minus C to  $I_1$  &  $I_2$ . Bias on  $I_1$  and  $I_2$  maintained constant at  $-6$  volts." Do  $I_1$  and  $I_2$  refer here, as elsewhere in your notes, to the first and second intermediate frequency transformer tube stages? A. That's correct, yes.

Q. 622. Or to the tubes themselves? A. Really the stage including the tubes and associated circuits.

Q. 623. Opposite this page 54 there are various measurements and there is also a curve sheet attached to it. What was the automatic gain control that was employed in these measurements? A. Well, that's the automatic gain control circuit that we had in the set on which we were measuring—the laboratory setup. There are really two parts to an investigation of this automatic gain control action. Those we have been just discussing in the last few pages here, had to do with the effect on the intermediate frequency characteristic that was obtained



by changing the bias on the intermediate frequency tubes, that is, we didn't want to spoil the fidelity characteristic, and that was really one part of the investigation. In other words, how could we control the gain without spoiling that characteristic. The second was where we would obtain the voltage to do that controlling. Actually the set had been hooked up and had worked before that time, but these measurements had to do with how good it was, that is, what we had set as the premise of this investigation was that we were endeavoring to build the best set possible. We did not want to do anything that would detract from its performance characteristics. This particular set of measurements beginning on page 54 therefore have to do with where we would obtain the control voltage from. For this particular measurement here, we obtained the feed for our automatic gain control amplifier system from a 250 micromicrofarad condenser, which is shown in the circuit here, as a part of the second filter, the filter preceding the second detector. It is shown here. This condenser is shown before and on later drawings.

Mr. Guild: Referring to Exhibit 2.

Q. 624. Now this condenser was connected to a filter input circuit in the second detector? A. That's correct.

Q. 625. Where did the lead from that condenser go? A. Well, that second filter consisted of really two transformer circuits linked by an intermediate coupling circuit, and this condenser was in that intermediate coupling circuit. The circuit consisted of two coils, one in each transformer circuit, and with the coupling condenser between them.

Q. 626. Where did this condenser lead to with respect to the automatic gain control? A. Well, the grid of the fourth intermediate frequency amplifier, which was part of the automatic gain control circuit, was connected to



one side, and its filament to the other side of that condenser.

Q. 627. That is, one side of the condenser was connected to the grid of an additional intermediate frequency amplifier tube. Was the plate of this last tube connected to anything? A. The plate of the fourth intermediate frequency?

Q. 628. Yes. A. That was connected to another transformer entirely separate. That transformer was part of the automatic gain control circuit.

Q. 629. What was on the output of that last transformer? A. The control rectifier circuit.

Q. 630. And where did the output of that control rectifier circuit or tube go to? A. Well, that fed a resistance across which the gain control voltage was developed.

Mr. Guild: During this testimony the witness has been referring to Exhibit 2 and previously to Exhibit 4A.

Q. 631. Are those the only exhibits you have been referring to, Mr. Scarr, during your testimony?

Mr. Guild: After his reference to page 54.

A. I believe the same condensers are shown on others of the circuits which happen to be handy. I believe there is one circuit there that shows a little bit more definitely how that was hooked on.

Q. 632. I show you Plaintiff's Exhibit 10. Does that show the arrangement which you have just described?

A. It does, except for the point of input for the method of obtaining the input voltage to the automatic gain control system. This shows the system which was later adopted of a separate coupling coil, while the system having to do with these measurements on page 54 obtained that voltage from a different point.

Q. 633. On page 56 under date of 12/7/25— A. (interrupting). Well that really has to do—we discovered

from this information on page 54 that it had an undesirable effect on our intermediate frequency characteristic. It distorted it on one side, so that we discovered we would have to find some other means of coupling. We thought possibly the grid plate capacity of the tube caused the difficulty, due to its being hooked across the coupling capacity, so that for the next pages we attempted to adjust the value of the condenser to compensate for that possible effect, that is, pages 56 and 57. On that particular investigation we changed the 250 micromicrofarads to 200 micromicrofarads and found that the characteristic was still distorted. On the next page we changed it to 210, and from the data the characteristic was still distorted, then we changed it to 220, the characteristic was still distorted, and 230, the same result, so that then we decided we were on the wrong track as to the distortion, that it might be possibly too effective grounding on the one side of the capacity, so we made a test then grounding one side of the condenser to determine what the effect due to that ground was. Those tests went on over to December 9th, and then the effect of that ground did not change the picture any as regards the distortion characteristic, so using a precision variable condenser we tried other values for that filter condenser. That whole investigation carried over to 12/15, about December 15th.

Q. 634. 1925? A. 1925.

Q. 635. I show you Plaintiff's Exhibit 12, which has the words among others: "Modified by P. H. Betts on or about Dec. 15, 1925. W. & U. H. F. Scarr 1/14/26". Did you write the words on the original of this paper, W & U, H. F. Scarr, 1/14/26? A. I did.

Q. 636. On or about that date? A. I did, yes.

Q. 637. Did you understand the circuits that are shown on that paper as of the time that you wrote your name



on it? A. Yes, certainly. That shows the circuit that we were testing.

Q. 638. Now you referred to some condenser which was connected in the filter circuit in the input of the second detector, and whose value you changed from time to time in order to get better fidelity characteristics. Is that shown in that circuit? A. It is. It is shown in the transformer circuit, well it is really between the transformer labelled W2648 and W6415, and the condenser is marked .00025. It is this condenser here at the bottom of the circuit (indicating). Incidentally, you can see here fine lines showing where that gain control tube was connected, the grid being connected to this side of the condenser, and the filament circuit to that side. That shows the circuit we were just discussing. We later abandoned the idea of working across that condenser and used this separate coil, which is sort of squeezed in between the other two there. That was the final solution of obtaining that input voltage.

Mr. Guild: Would you ask him to describe what he meant by "this" and "that" connection that he is talking about?

Mr. Philbin: Yes, sir. You are so asked, Mr. Witness.

The Witness: Well, the marks of where a line has been erased ran from the grid of the fourth intermediate frequency tube to one side of that .00025 condenser, and there's another line running from the filament side of that tube to the other side of the condenser. That second line isn't connected directly to the filament, but it is effectively so as regards the intermediate frequency because it is connected to the filament through a condenser and the actual DC circuit depended upon the bias on that particular tube.



Q. 639. In your last answer have you been referring to the original paper, which constitutes Plaintiff's Exhibit 12? A. Yes, I have.

Q. 640. Now after the date of December 15, 1925, what do your notes show that you did with respect to automatic volume control? A. Well, on December 19th on page 84 and page 85 we show tests on a new circuit, in which we used a coupling coil in that filter circuit instead of attempting to connect our gain control system across the filter condenser, and the results of these tests shown by that circuit are shown on a curve dated December 19, 1925. There are two curves shown, one marked "normal" and the second marked "gain control hooked in", the normal being without the gain control hooked in, and the curves are almost identical and lie very near each other, showing that the adverse effect on the fidelity characteristic on the intermediate frequency system had been eliminated, that is, the adverse effect of connecting any automatic gain control circuit had been eliminated.

Q. 641. Then what did you do, as shown by your notebook? A. Well, the next investigation was to proportion the constants of the gain control circuits, particularly the resistance in the rectifier circuit, so that the desired voltage change would be secured, which would approach the optimum value for adjusting the gain when applied to the intermediate frequency tubes—would be the optimum value for controlling the gain. These particular tests were started in—I guess I am just a little bit ahead of myself. This particular test has to do with the tuning and coupling transformer between the fourth intermediate frequency stage and the control rectifier tube. We determined that it would be desirable to make the characteristic of that transformer more peaked or to cover a narrower frequency band than did the intermediate frequency amplifying system, and this particular entry

in the fifth column of page 87 showed the effect on that transformer of tuning it with a pigtail condenser.

Q. 642. Referring to Plaintiff's Exhibit 10, can you tell us which is the transformer shown in it, to which you have just referred? A. Is that the one marked L13?

Mr. Philbin: I have just marked L13 on that exhibit because the transformer between the IF amplifier and the AVC rectifier was referred to in the testimony of Mr. Nelson and also in the testimony of this witness.

The Witness: Let's see. There are some curves here. This curve is the one marked "See lab. book 49 page 87 December 2, 1925." It shows the frequency characteristic of that transformer L13, and the fact that there are two curves there, one centering around 81.7 kilocycles and the other 83 kilocycles shows the effect of adjusting that pigtail cutoff condenser that I referred to a moment ago, tuning at 83 kilocycles which was our chosen frequency rather than 81.7, which would not bring it out right.

Q. 643. What was this transformer L13 tuned at, that is, what frequency? A. We tuned by this pigtail condenser to a midband frequency of 83 kilocycles. Actually it passed more than just 83 kilocycles. It had a rounded top but it passed between 82 and 84 kilocycles fairly well, and fell off quite rapidly, outside of that.

Q. 644. Why did you tune this transformer to 83 kilocycles with a margin of about 1,000 kilocycles on each side? A. Well, if we had not had some sort of device like this, the gain control circuit would have operated on a characteristic determined by the characteristic of the intermediate frequency circuits, in other words, changing the carrier frequency, a matter of 5,000 cycles away

from 83 kilocycles, would not have caused the automatic gain control to function, that is, no change in the gain. The input to the gain control rectifier circuit would have remained substantially constant and the bias which it supplied to the intermediate frequency tubes would therefore remain substantially the same, and the gain would have remained substantially the same, and that was not desirable. We wanted our automatic gain control circuit to operate more quickly than that, that is, to respond with less variation of the carrier frequency from the tuning of the set because of the characteristics of the radio frequency portion of the set. The radio frequency circuits were designed for great selectivity, and as the carrier frequency moved away, assuming that the tuning of the set remained constant and that the carrier frequency were changed away from the mid-tuning of the set, the input from the radio frequency portion would fall off quite rapidly due to the selectivity characteristics of the set, and we wanted our gain control to compensate for that, bringing up the gain so that the output of the set would remain substantially constant, even though the carrier frequency were off of the exact tuning of the set. It would possibly be better to look at it the other way around, by tuning the set holding the carrier frequency constant and changing the tuning of the set.

Q. 645. What would make the intermediate frequency be off 5,000 cycles or so? A. Well, changing the tuning of the set, the fact that the set was not tuned exactly to the carrier frequency.

Q. 646. So that this transformer L13 was tuned in order to compensate for any off tuning that there might be in the radio frequency part, is that right? A. Yes, that's correct. Incidentally, this also gives a method of obtaining a tuning indicator. The current through the control rectifier plate circuit was maximum at the point



it received maximum input, and this transformer determined that that maximum input would occur at 83 kilocycles, so that by putting the meter in that plate circuit, we could determine when the incoming carrier beating against the frequency changing circuit produced an intermediate frequency of exactly 83 kilocycles, by the fact that the maximum deflection occurred on that tuning meter.

Q. 647. Was this tuning meter used in the plate circuit of the automatic gain control rectifier? A. It was, yes.

Q. 648. Now refer again to your notebook and state what it shows with respect to further work on your part on automatic gain control arrangements. A. Well on pages 88 and 89, dated December 23, 1925, we began to investigate the optimum values for the resistance in the plate circuit of the control tube across which the gain control voltage would be developed.

Q. 649. And does your notebook show from that date on the results of measurements of automatic gain control circuits employing different values of resistances in the plate circuit of the automatic gain control rectifier? A. That's right, it does.

Q. 650. And there are also curves showing those different results? A. Yes, sir, that's right.

Q. 651. Will you state generally what those curves show, with respect to the tendency on automatic gain control, of using small sized, medium sized and large sized resistances? A. Well, that effect is best shown, for the result of all these tests, on the curve that is pasted to page 98, in which various values of resistances are shown connected to various curves, and these resistances were those used in the plate circuit to the gain control rectifier tube, and then the curve shows millivolts input plotted against gain. It is not shown on the curve,

but the shape of this curve is characteristic of that type of curve, and by looking at the data here on these pages we can see millivolts input—

Q. 652. Well, now, according to this curve sheet, which, as I understand, represents in graphic form figures which are in your notebook— A. Right.

Q. 653. —values of resistances used as follows, viz.: 5,000 ohms, 10,000 ohms, 20,000 ohms? A. That is for 30; it is not marked.

Q. 654. Non-marked curve, then 40,000 ohms and 80,000 ohms. Which of those curves show the most desirable automatic gain control situation? A. The 80,000 ohms represents the most desirable because we intended to keep the output substantially constant with varying values of input. The others are less desirable, although they show the effect of automatic gain control also, because while they do not maintain it nearly as constant as does the 80,000, they do maintain it more constant than they would be without a gain control circuit.

Mr. Philbin: This curve the witness is looking at is marked millivolts input along the abscissa.

Mr. Guild: Would you ask the witness to state what the ordinates are.

Q. 655. Will you do so? A. The ordinates represent the output of the set. I don't know just which of these figures are plotted, but we took the output current of the output tube through a fixed resistance and I believe that is plotted in the ordinates. That is, the ordinates are vertical.

Mr. Guild: State what kind of volts, AC or DC?

The Witness: DC, rectified AC, however.

Q. 656. Referring to the chart, Plaintiff's Exhibit 10, can you point in it to where the output was measured?

A. It was at the output of the set. It was at the output of the audio frequency tube.

Q. 657. At the bottom of this chart are the words millivolts input, and at the left there is a vertical line which has nothing marked against it. What does this vertical line tend to show? A. That tends to show volts output, rectified audio frequency voltage.

Q. 658. And the millivolts input was the input to what? A. To the modulator tube, the first detector tube.

Q. 659. Where was the resistance located, concerning which you have been testifying? A. You mean the resistance in the output circuit across which—I don't know just which resistance you mean.

(Resistance indicated by Mr. Philbin.)

A. (continuing) That resistance is in the gain control rectifier circuit, across which the gain control or bias voltage for the intermediate frequency tubes is generated.

Q. 660. In the chart, Plaintiff's Exhibit 10, is it marked R3? A. That's right, R3.

Q. 661. In the drawing, Plaintiff's Exhibit 12, is it also shown? A. I believe this is it. Well, I think this circuit was somewhat later changed, but that is the resistance, it is the one located right under the tube marked A. No, that doesn't identify it either. It is the variable resistance that is connected to the key, right under the tube marked A.

Q. 662. Now after you had finished your work on these resistances, and determining the optimum value, then what, if any, further work did you do on automatic gain control? A. Well, the next entry which is mine is on page 104, dated February 17, 1926, and the notation is that the set was rewired throughout, in other words, that we had made so many haywire changes on it that one change was getting in the way of another, and we had



made sufficient tests on the set so that we knew approximately what the constants should be, so that we rewired the set, cleaned it all up and removed the effects of those past changes and began to take tests on it again.

Q. 663. When did you complete your work with respect to the optimum value of these resistances? A. Well, it was about the first week in January. This data was taken on January 6th and I believe Mr. Fischer carried on with some more of them. This appears to be his writing on pages 100 to 103 in which his further investigation of that same problem goes down to January 12th. There is one point here that I didn't bring out. I don't know whether this is important or not at all, but this had to do with the method of reducing or controlling the amount of bias voltage which we had to apply to the intermediate frequency stages to obtain gain control.

Q. 664. How long did you continue working on these double detection receivers? A. Well off and on up until the time I left the laboratories around the first of September, 1926.

Q. 665. Are double detection receivers sometimes referred to as superheterodyne receivers? A. Yes, they are. In fact, that is the accepted term, nowadays.

Q. 666. I show you Plaintiff's Exhibit 1-A. Are they your initials on that exhibit? A. No.

Q. 667. And Exhibit 1-B? A. No.

Q. 668. Plaintiff's Exhibit 2 is a circuit diagram entitled "Drawn Dec. 30, 1925 by H. B. Fischer, witnessed and understood, P. H. Betts, 1/13/26, Henry F. Scarr, 1/13/26". Did you write your name on that paper? A. I did.

Q. 669. On the date indicated? A. On the date indicated, January 13, 1926.

Q. 670. Did you then understand that diagram? A. I did, yes.

Q. 671. Do you know whether or not that was a diagram of a contemplated prospective arrangement, or one that had already been set up? A. No, that is one that had been set up, but we wanted to get it down on paper.

Q. 672. That is, you had seen that arrangement before the date upon which— A. (interrupting) That was the circuit of the test equipment that we had been making our tests on, and you will note that it included this change, having the coupling coil here instead of working across the condenser, and a few things like that.

Q. 673. That is, at least by January 13, 1926 you had dropped out this condenser in the filter circuit? A. We had not dropped the condenser out. We were no longer hooking our automatic gain control condenser across it. There is an earlier circuit, I believe.

Q. 674. Referring to the memoranda, Plaintiff's Exhibits 3-A, 3-B and 3-C, dated respectively January 2 and 4, 1926, your name, Henry F. Scarr, appears on each of these memoranda. Did you write your name on those memoranda on or about January 2 and 4, 1926? A. I did, yes.

Q. 675. Did you read what was on the memoranda? A. I did.

Q. 676. Is what was on the memoranda at the time that you put your name there, what now appears on it? A. Yes.

Q. 677. Referring to Plaintiff's Exhibit 4-A entitled: "Schematic diagram of DDAC 1 radio receiver; drawn January 13, 1926 by Henry F. Scarr" and containing other words, did you draw that diagram? A. I did, on or before that date.

Q. 678. Was that a diagram of a contemplated or an actual receiver? A. Well, that was an actual receiver.

Q. 679. That is, it had been set up and operated on or before January 13, 1926? A. Yes, sir.

Q. 680. I show you Plaintiff's Exhibit 4-B which has the same title as Plaintiff's Exhibit 4-C, but with some additional words noted thereon. Do you recognize that diagram? A. I recognize that, yes. That's just a further copy of the same drawing. We made some further changes on it, and the changes are shown there.

Q. 681. Referring to Plaintiff's Exhibit 4-C, which is a photostatic copy entitled: "Potential diagram per January 13, 1926, schematic DDAC radio receiver", can you recognize that? A. I have seen that, yes, on or about the date it was made.

Q. 682. What relation does it bear to the schematic diagram? A. It is a DC diagram of the same circuit, that is, it eliminates all the radio frequency portions of it, and simply covers the supply circuits for the filaments and for the plate voltages, the fixed grid voltages, and that sort of thing.

Q. 683. Referring to Plaintiff's Exhibit 4-D, which is entitled: "Schematic diagram for DDAC-1 radio receiver, circuit revision of Feb. 26, 1926, and which has on it: "H. F. Scarr, 3/2/26" under the words "Witnessed and Understood by", did you write your name on that original diagram? A. I did, on that date.

Q. 684. Did you then understand that receiver diagram? A. I did, yes.

Q. 685. Do you know whether or not it was in existence at the time the diagram was made, or before such time? A. Yes, a set substantially in accordance with that diagram.

Q. 686. Plaintiff's Exhibit 4-E appears to be a copy of Plaintiff's Exhibit 4-C? A. Yes, those diagrams were really made for mechanical design purposes.

Q. 687. You have been referring to Plaintiff's Exhibits 5, 6 and 7? A. Yes.

Q. 688. And those are dated April 24, 1926 and subse-



quently, are they not? A. That's correct, yes. The set was really beginning to emerge from a circuit design stage more into a mechanical design stage at that time, that is, into a set which might be sold commercially.

Q. 689. I show you Plaintiff's Exhibit 4B-1, which appears to be the original of Plaintiff's Exhibit 4-B. Is that the original paper which you drew on January 13, 1926? A. Yes, sir.

Q. 690. I also show you Plaintiff's Exhibit 4E-A, entitled: "Schematic diagram for DDAC-1 radio receiver, circuit revision of February 26, 1926" and which appears to be the original of Plaintiff's Exhibit 4E-A. Did you write your name on that paper on March 2, 1926? A. I did.

Q. 691. And did you then understand that diagram? A. I did.

Q. 692. Referring to Plaintiff's Exhibit 12, having the words "Modified by P. H. Betts on or about Dec. 15, 1926, W & U, H. F. Scarr 1/14/26", did you write your name on that paper on January 14, 1926? A. I did.

Q. 693. Was the receiver which is shown in that circuit diagram in existence on or before January 14, 1926? A. Yes, it was in existence before December 15th.

Q. 694. What did you have to do with that receiver before January 14, 1926? A. Well, this is the diagram that I had with me in the laboratory during the tests that are shown in the notebook, on which changes were made from time to time. This change through the condenser is on this diagram; the faint pencil marks are still visible there.

Q. 695. I show you Plaintiff's Exhibit 13 entitled: "Tentative current sheet for circuit as of December 15, 1925, DDAC-1 receiver". Do you recognize that paper? A. I do. I didn't draw it, but I recall its having been drawn. I believe Mr. Betts drew it.

Q. 696. Did you ever use it or see it in your work?  
A. Oh, yes. I used it in setting up the DC portions of the set which we made our tests on.

Q. 697. Did those DC portions include any automatic volume control circuits? A. Well, they included the supply for the rectifier tube and the power supply for it. This doesn't show any of the audio, radio or intermediate frequency circuits, simply the power supplied to them, and it shows the filament circuits for those tubes, and the method of obtaining their plate voltages, grid voltages, and that sort of thing.

Q. 698. Does it show the way the plate voltage and the filament voltage was obtained for the automatic gain control rectifier? A. Yes, it does.

Q. 699. And the amount of voltage that was used for the automatic gain control rectifier? A. It does.

Q. 700. And was that the amount of voltage that you used? A. Yes, it was.

Q. 701. As of what date? A. Well, certainly before this date. This diagram really is the result of laboratory tests and represents values chosen before the date of the diagram.

Q. 702. And that date is December 15, 1925? A. Yes.

Q. 703. Referring to Plaintiff's Exhibit 14, entitled: "Modification of Dec. 30, 1925 circuit, showing new filter arrangement, P. H. Betts Jan. 4, 1926, W & U, Henry F. Scarr 1/13/26"; did you write your name on that paper on January 13, 1926? A. I did.

Q. 704. Did you then understand that arrangement? A. I did.

Q. 705. Was that diagram of a previously existing receiver? A. Well, this showed the portion of a circuit of an existing receiver. This covers really the power supply circuits and the location of the control rectifier tube in that circuit, the method of obtaining both fila-

ment and plate and other voltages for operation of the set from a single power rectifier circuit.

Q. 706. Does it show the automatic gain control rectifier? A. That's the tube marked C.

Q. 707. Does it show the amplifier tube stage for the automatic gain rectifier, which you have sometimes referred to as the fourth intermediate frequency tube? A. Yes, that tube is marked 4.

Q. 708. Plaintiff's Exhibit 15 is entitled: "Direct diagram per Jan. 4, 1926, circuit DDAC radio receiver". Do you recognize that diagram? A. Yes, I do. That's a revision of the previous drawing that is dated December 15th, Exhibit number 13.

Q. 709. Referring again to Plaintiff's Exhibit 12, which shows a circuit diagram apparently witnessed by you on January 14, 1926, does that show a tuning meter in the plate circuit of the automatic gain control rectifier? A. It does. It is immediately below the key. I believe there is a mark in blue pencil, D, right on top of it.

Q. 710. Is such tuning meter so located also shown in Plaintiff's Exhibit 4B-1, which is a drawing apparently made by you on January 13, 1926? A. It is meter marked TI, near the key.

Mr. Philbin: Plaintiff offers in evidence the notebook referred to by the witness, as Plaintiff's Exhibit 18. Does defendant's counsel desire to examine this notebook?

Mr. Guild: Defendant's counsel does.

Mr. Philbin: I will now hand the notebook to defendant's counsel. It is stipulated that plaintiff may offer photostat copies of pages from this notebook, such pages to include any requested by defendant's counsel, with the same force and effect as the originals of such pages would have.



(Notebook received in evidence and marked Plaintiff's Exhibit 18).

Mr. Guild: It is understood that meanwhile the notebook will be left in Mr. Scarr's custody at 195 Broadway, where counsel for defendant may have access to it at reasonable times.

DIRECT EXAMINATION CLOSED

(The parties adjourn to another room, where a set is operated).

PHILANDER H. BETTS, recalled as a witness, further testified as follows:

*Re-direct examination by Mr. Philbin:*

Q. 711. Is Plaintiff's Exhibit 11 now operating? A. It is.

Q. 712. What is it connected to, that is, what kind of a loud speaker? A. 568 Western Electric loud speaker.

Q. 713. What is the input to this set, that is, what kind of an antenna is being employed? A. I have been told it is a 250 foot antenna outside the building connected to a transmission line to an outlet box on the wall that is terminated to a coupling coil here in the middle of the table and the area space between that coupling coil and the other similar coil which is connected across the antenna and ground connections of the radio receiver. The receiver is at present tuned to 660 kilocycles for radio station WEAFF program, and we have arranged this antenna coupling circuit external to the set to show the capabilities of it with respect to automatic volume control. At the present time it is operating with the set complete with automatic volume control with no changes

made in any part of the circuit. It will be noted that the antenna coupling coil or the one connected to the antenna can be used at a distance of approximately ten inches without changing the output level appreciably. I will remove from the set the tube which is the control rectifier (doing so).

Q. 714. What is the result of removing the control rectifier? A. As it happened, I have the antenna coupling at that point at which the level was the same. If I now increase the coupling from the antenna—(there is a louder noise).

Q. 715. What is the result? A. It will be noticed that there is a considerable change in the output level of the set.

Q. 716. Was changing that antenna coupling coil the same as keeping the antenna coupling the same, but with a greater signal coming in? A. That would be equivalent to that, inasmuch as you are dealing with a fixed signal. We have introduced this coupling to produce a variable strength of signal as far as the set itself is concerned.

Mr. Guild: What was that tube, the rectifier or amplifier?

The Witness: That is the control rectifier tube.

Q. 717. You spoke of a considerable difference. How much difference was observed? A. Well, with the coupling increased, the output approached the overload point, so that the volume was increased to a point where no greater volume could be obtained from the output tubes.

Q. 718. How much difference in noise was there, approximately? A. I should estimate about 40 db. difference there in level. However, the measurement value for this set shows a control of approximately 80 db. in input level will cause a change of approximately 6 db. in output.

Q. 719. What does db. mean? A. Decibel.

Q. 720. What does that mean? A. That is a term used to express ratios to power or voltage or current. One decibel equals 20 times the logarithm of the ratios of two, or ten times the logarithm of the ratio of power.

Q. 721. How many decibels is ordinary speech? A. It can't be expressed as directly as that, because in ordinary use it means the ratios to power and not a definite reference to any particular or absolute level, unless the level itself is stated as a reference point.

Q. 722. How many decibels would there be between a whisper and a shout. A. I am not qualified to state. However, I should imagine it might be as much as 50 db.

Q. 723. How does the quality of this set as now operating compare with sets as of 1925? A. I believe it is the most selective set that I have ever listened to or had the opportunity of operating up to 1925.

Q. 724. How does it compare with present day sets? A. Quite well. We have no difficulty in separating stations 25 kilocycles.

Q. 725. With respect to sensitivity how does it compare first with sets up to 1925 and with sets of today. I am referring to ordinary receiver sets on the market?

A. With respect to sets of 1925 it had about as much sensitivity as it was then possible to build in any laboratory setup. Since then of course developments have made it possible to get far greater gain even in sets which are sold commercially today, in other words, have far greater sensitivity in the high gain sets.

(There is a change made in the set.)

Q. 726. Is there a tuning indicator on this set? A. There is, right in the center top dial.

Q. 727. What does that tuning indicator show? A. That really states the current of the control rectifier tube. Maximum deflection is the point which is tuned for in tuning the receiver.



Mr. Philbin: That concludes the examination of this witness with respect to the set. Defendant's counsel may ask such questions and request such operation of the set as he may desire.

Defendant's representative, Dr. Wheeler, is now operating the set.

(Discussion between Mr. Betts and Dr. Wheeler).

ADJOURNED EXAMINATION held at the offices of Messrs. Fish, Richardson & Neave, 20 Exchange Place, Borough of Manhattan, New York City, on Monday, September 16, 1935, at 11:00 A. M.

APPEARANCES:

STEPHEN H. PHILBIN, Esq.,  
J. G. NORTON, Esq.,  
Counsel for Plaintiff;

WILLIAM H. DAVIS, Esq., and  
BALDWIN GUILD, Esq.,  
Counsel for Defendant;  
MR. LANGLEY.

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HENRY F. SCARR resumed the stand and further testified as follows:

*Cross-examination by Mr. Davis:*

Q. 728. Will you please give us the full meaning of the abbreviated title on the inner cover of your notebook: "Double Detection Rec. Osc. Design"? A. Double detection of course means double detection receiver oscillator design.

Q. 729. Did you have any other notebook or notebooks in which you recorded experiments or measurements on the other portions of the set, such as the intermediate frequency circuit design, or the automatic volume control circuit design? A. No, this is the only notebook that I had for the job. Other pieces of paper such as circuits and that sort of thing are occasionally recorded outside of this, but this was the notebook for the job.

Q. 730. Now will you look at the June 18, 1925 entry? A. Yes, page 1.

Q. 731. Is there anything on that entry to indicate that it had anything to do with a receiver equipped or to be equipped with automatic volume control? A. No, that entry has nothing to do with automatic volume control directly.

Q. 732. That is, it has to do with the matter of oscillator design, hasn't it? A. Yes, oscillator design, but the double detection receiver is what they had in mind.

Q. 733. Well, now, Mr. Scarr, the double detection receiver that you now have in your mind and that you just referred to, is the one that finally was developed into the DDAC receiver and 7A receiver? A. Yes.

Q. 734. Mr. Betts' testimony here led to the production of a memorandum which was marked Exhibit 1A and dated September 14, 1925, and I direct your attention to this memorandum, of which the first sentence is as follows: "This memorandum outlines the work about to be done in the development of a radio receiver of the double detection type, deriving its energy from an alternating current source." Now is that the first memorandum about the development of this particular receiver? A. I think perhaps it is, although that doesn't mean that we had not considered it before. We had not done work on it before. This was really the first information that had been prepared for people up the line in our organi-

zation to give them some idea of what we had in mind.

Q. 735. Well, that memorandum referred to a circuit diagram which was put in evidence, Exhibit 1-B and dated September 9, 1925, that circuit diagram, as I understand it, was the diagram of the double detection receiver which was to be developed? A. That was a tentative diagram.

Q. 736. It contained no indication of the use of automatic volume control, did it? A. That is correct, it didn't.

Q. 737. In fact, it had the manual volume control, didn't it? A. Yes.

Q. 738. Well, there is nothing in your notebooks, no recorded entry that goes to show any circuit diagram or any other evidence of even the intention to use automatic volume control prior to the date of this memorandum of September 9, 1925, is there? A. (after consulting book). I find no notebook entry prior to that September 14th date which refers directly to automatic control.

Q. 739. You don't find any entry, Mr. Scarr, that refers at all to automatic gain control, do you? A. No, that's true; that's before that date.

Q. 740. When you were being questioned by Mr. Philbin, referring to Q. 568, he asked you first to tell us, now I am quoting: "What work you did on or about June 18, 1925 in connection with this 'Double Detection Receiver'," and you replied that the entry of June 18, 1925 had to do with an investigation of the oscillator design. Then Mr. Philbin asked you if you recall "whether or not there was any automatic gain control used at any time with these receivers" and you said: "Yes, there was automatic gain control used in connection with these sets". Your meaning there was that as a subsequent development of the double detection receiver the auto-



matic gain control, was used, is that right? A. Well, it is impossible for me to recall after such great period of time just when we first considered the use of automatic gain control for these sets, but I feel that we probably discussed it in the very earlier stages, and the decision to apply it to this particular set may have come later than this memorandum of September 14th, but we have no entries to prove that we did discuss it, before that.

Q. 741. Well, there is no entry in your notebook that refers at all to automatic volume control until the entry on page 54, is there, I think that is the page, under date of December 2, 1925? A. That is the first definite entry in which automatic volume control or automatic gain control was mentioned.

Q. 742. Well, again referring back to your answer to Mr. Philbin's question 569 which is on page 171 of the testimony, you didn't mean there to say that automatic gain control was used on or about June 18, 1925, but merely to say that at some time in the subsequent development of that double detection receiver automatic gain control was used? A. That's right.

Q. 743. Now you said in answer to question 572 that you discussed automatic gain control with Mr. Friis. I suppose you were referring to Mr. Harald T. Friis? A. I don't know his initials, unfortunately. The Friis I referred to is the man who at that time was a member of the Research Group of the Bell Laboratories.

Q. 744. Did you know anything about the work that Mr. Friis had done before 1925 in connection with automatic volume control? A. As far as I recall, we discussed some of his investigations which had been made prior to that time, which included a method of obtaining automatic control of gain.

Q. 745. Do you recall whether or not you discussed at that time, and we are talking now about the summer of

1925 or some date prior to this entry on page 54 of your notebook, do you recall whether you knew the character of the particular form of automatic gain control that had been applied by Mr. Friis to a heterodyne receiver, and which is illustrated in his patent, number 1,675,848 which I show you (handing patent to witness)? A. That shows the basic principle which we later used in the particular application of automatic gain control that we made and it is my recollection that Mr. Friis explained this principle to us before we initiated tests on the set we were designing to determine how we could apply that principle to it and what results would come forth from such application.

Q. 746. That is, your present recollection is that before you began to make tests on the actual application of automatic gain control to these DDAC receivers, you knew about this Friis work and the nature of his work? A. Yes. We really had to know that so that we would know what test to make.

Q. 747. Well, now, I want to avoid if I can, Mr. Scarr, the failing that all of us have, and that is remembering by reasoning, but I would rather try to get at what you really recall and what I'd like to have you put your mind on at the moment is this, that some time, we are not concerned with the time at the moment, you began to apply automatic gain control to this double detection receiver. The record shows that before that time Mr. Friis had applied automatic gain control to a heterodyne or double detection receiver. Now do you recall whether you knew that fact, that Mr. Friis had previously applied automatic gain control? A. It is my recollection that I did.

Q. 748. That is, your recollection is that you were in this state of mind when you started that work, that you knew that automatic gain control had been applied by

Mr. Friis in the laboratories of the Company to a heterodyne radio receiver? A. That's right.

Q. 749. Now am I correct in understanding from your testimony, and you can refer to page 172, that prior to the first of September, 1925 you had been working on the radio frequency end of the set and that on or about the first of September you began an investigation of the intermediate frequency portion of the set? A. Yes.

Q. 750. And the radio frequency portion of the set included the oscillator design, is that right? A. Yes, that's right.

Q. 751. Now, then, the entry on page 31 of your notebook, under date of November 16, 1925, has to do, as I understand it, with measurements of the frequency characteristics of this set, which is referred to as Lab. Model No. 1, is that right? A. That is correct.

Q. 752. That is, at this point you were trying to find out what the characteristics of the intermediate frequency circuits were, and without any gain control applied, is that right? A. Yes, that entry was the measurement of the intermediate frequency characteristic end, when the gain was held constant, for a given value of gain.

Q. 753. I am more or less a layman on this thing. That means the same thing as without any gain control? A. Well, not necessarily. It means with the gain control at a single setting, that is, without changing the gain control. That is, we held the gain substantially constant and made the frequency characteristic over—

Q. 754. Well, you had means, as I understand it, Mr. Searr, for manually controlling the gain, is that right? A. Yes.

Q. 755. How was that done? A. That was done by controlling the voltage applied to the circuit of the intermediate frequency tubes, the grids of those tubes, through the manual, the operative potentiality.



Q. 756. And in these measurements on page 31 of November 16, 1925, as I understand it, there was no variation of the gain control; it was constant gain? A. Correct.

Q. 757. Now, then, on page 34 under date of November 18, 1925, the entries which you testified about on page 174 of your testimony, and as to which you said that the measurements were made, that on this particular test you determined "what happened when we caused the second and third intermediate stages to cease to amplify". And you went on to say that you caused these stages to cease to amplify by biasing the grid of one tube, and then the other and then both, is that right? A. Well, for that particular entry they were both cut out.

Q. 759. In that entry the bias was applied to both of the grids, is that right? A. That was my recollection at the time I testified previously, that there was nothing in my notes here to substantiate the belief that those two tubes were cut out by means of applying negative voltage to the grids. I think from looking at this information now that perhaps those two tubes were left out of the amplifying chain for that particular test, rather than having caused them to cease to amplify by means of reducing or increasing the bias.

Q. 760. Well, in that case the measurements show whether the elimination of two of the amplifier tubes would change the intermediate frequency characteristic? A. Well, that was one thing we were trying to find out. The other was how much of the amplification was accounted for by that first stage in the amplifier.

Q. 761. Well, but on page 175 you said this: You said, "we were not interested so much in how much the gain was reduced, but what reducing this gain did to the intermediate frequency characteristic, and that's what

the data taken in this particular test was to prove, that when the gain was reduced very low on the second and third stages the intermediate frequency characteristic would be still of a desirable form." And now I take it what you should have said was that the data taken in this particular test proved that when the two amplifier tubes were eliminated from the system the intermediate frequency characteristic would still be in a desirable form, is that right? A. Well, I should have also said that we were interested in how much gain was obtained from that first tube, and if I had taken sufficient time to compare those two curves my testimony as to the amount the gain was reduced, instead of saying the notes don't cover that point, would have been that it was reduced from a value of approximately 83 T. U. for the three stage amplifier, as shown on the curve attached to page 33, to a value of slightly less than 35 T. U. for the single stage, as shown on the curve attached to page 35, or roughly a decrease of 50 T. U.

Mr. Philbin: You might put in parenthesis what T. U. means, for convenience.

The Witness: Transmission unit, being a measure of gain.

Q. 762. Well, Mr. Scarr, Mr. Philbin in his next question, that is, question 587 on page 175, said: "That is, these measurements were to determine what would happen if you used automatic gain control, with respect to the fidelity characteristic?" and you answered: "That's correct, yes." Now, as a matter of fact, you now testify that there was not only no automatic gain control in these measurements, but no gain control at all, is that right, either automatic or manual? A. Well, there was no readjustment of the gain of the set during those tests.

Q. 764. And the reduction or elimination rather, of the

second and third stage of intermediate frequency amplification was not done by gain control, but by cutting out those two stages? A. Yes, cutting them out from the amplifying chain.

Q. 765. Now on the next page of the testimony, page 176, referring to your entry on page 36 of your notebook under date of November 23, 1925, you said that these measurements were started but were stopped at that time "because we found we needed to know a little more about some of the other circuits before we made that particular test, so that on the next two pages, under the same date, November 23rd, we took some more intermediate frequency characteristics. This particular one referred to the intermediate frequency characteristic when the bias on the first intermediate frequency tube was reduced to minus 30 volts." Now what particular one were you referring to? A. The data is shown on page 39, and the title is shown on page 38 of the notebook.

Q. 766. Your notebook doesn't show, does it, how you varied the bias on the tube, that is, by what means? A. No, it doesn't.

Q. 767. Do you remember how you did it. A. Well, for this particular condition we of course held the bias on the first intermediate tube at minus 30 volts, and I presume that we may have used the supply. I don't recall where we got the 30 volts from.

Q. 768. Well, you didn't get them from any automatic gain control, did you? A. No, because that would have varied with input.

Q. 769. In your testimony on page 176 you speak of reducing the bias to minus 30 volts, first on the first intermediate frequency tube and then on the second intermediate frequency tube. Does that indicate that you had some means there for reducing the bias and voltage from some larger value down to 30 volts? A. No, I used "reducing"



there in the sense of reducing it below a zero voltage and direct negative voltage, that is, instead of increasing.

Q. 770. You don't recall how you got the voltage for those particular measurements? A. No, it has been some time.

Q. 771. Now on page 177 Mr. Philbin asked you this question: Q. 591. He said: "Then, as I understand it, on November 18, 1925 you commenced ascertaining what effect with respect to fidelity automatic gain control would have, first trying it on two tubes together and then trying it on each tube separately, is that right?" and you said, A. "That's correct, yes." Now the fact is that you weren't trying automatic gain control on those tubes, were you? A. Well, the measurements could not have been made with the automatic gain control controlling the gain and still trying to take a frequency characteristic, because one of the terms for a frequency characteristic is that the gain be held fixed for a given condition.

Q. 772. And the fact is that by some means, which you do not now recollect you fixed the bias on those tubes at a certain value? A. That's right.

Q. 773. And that there was nothing automatic about it, is that right? A. There is nothing automatic about the condition of the test. The place where automatic volume control came in was that it was necessary that we know what changing the gain did to the frequency characteristic, with the object of later changing it automatically.

Q. 774. Yes, but you had to have the same information if your object had been later to change it manually, wouldn't you? A. Substantially the same.

Q. 775. In other words, Mr. Scarr, the test was to find what would be the characteristic of the intermediate frequency system with a given bias on the tubes. You wanted to know whether changing the bias on the tubes would change the characteristics of the circuit, and the reason

you wanted to know that was that gain control was contemplated, and gain control would change the bias on the tubes, is that a fair statement? A. That's right.

Q. 776. And Mr. Philbin's question which first refers to automatic gain control then refers to trying it on the two tubes, when you answered that question "Yes", you didn't mean to say that you had at that time used automatic gain control at all, did you? A. Well, the circuit that we were making the tests on had been practically complete except with regard to the size of some of the constants for optimum operation, and the set that we were making the tests on did incorporate an automatic gain control circuit, as I recall.

Q. 777. You mean it afterwards incorporated an automatic gain control circuit? A. Well, it did at the time these tests were made, but it was not operating to control the gain during the time the tests were made.

Q. 778. Well, I will come back to this question of what was in the set again, so if you put that out of your mind but for the moment, my difficulty is this question. Q. 591 is so worded as to seem to say that "it", that is, "automatic gain control", was used by you on November 18, 1925 and the following dates recorded in this notebook that we have just been discussing. Now that isn't correct, is it? If you don't understand it, Mr. Scarr, the question as Mr. Philbin phrased it when you answered it "yes" seems to say that on November 18, 1925 you commenced trying automatic gain control on two tubes together and then trying it on each tube separately. What I want you to agree is that on November 18, 1925 you did not commence using automatic gain control at all, on any tubes, is that right? A. Well, I don't know whether we commenced using it on that particular date, but I know that we had used it on or before that date.

Q. 779. Yes, but let's stick to your notebook entries.

These notebook measurements didn't use automatic gain control at all? A. For these measurements we didn't use automatic gain control, that is, for this particular entry covering the intermediate frequency characteristic.

Q. 780. What you mean, as I understand it, is that there is no entry in your notebook that indicates that you used automatic gain control at all, prior to the entry on page 54? A. Well, there is no direct reference to automatic gain control before that point in the book.

Q. 781. Well, then, as I understand it, after these measurements of the fidelity of the intermediate frequency circuits with different biasing voltages on the grids, you proceeded to make measurements to determine how much voltage variation on the grid was necessary to control the amplification from the cut-off point to practically maximum amplification, is that right? A. That's correct.

Q. 782. And that's what you were doing in your entries on page 42 under date of November 24, 1925? A. That's 42 and 43.

Q. 783. Then, as I understand it, Mr. Scarr, that information would have been usable with any form of gain control, whether manual or automatic, is that right? A. That's right, yes.

Q. 784. Now referring to pages 48 and 49 under date of November 27, 1925, you testified that there you "wanted to see what effect balancing would have on changing the peaks and valleys in that curve", and you added: "Well, really neutralizing, that's what it amounted to, with a small capacity condenser, but this particular data on pages 48 and 49 shows that it was impossible to prevent singing or oscillation on the first intermediate stage", etc. Will you make that a little clearer, that is, just what do those entries on pages 48 and 49 refer to? A. I am afraid I don't recall anything further than what



I testified previously, that is, just how it was impossible to prevent that singing.

Q. 785. Well, my difficulty, Mr. Scarr, was that I didn't understand what you testified to before, that is, you said you wanted to see what effect balancing would have on changing the peaks and valleys in the curve and then you said: "Well, really neutralizing". On the whole did you intend to say that the work recorded on pages 48 and 49 was an attempt to effect balancing in the neutralizing sense and you found that it was impossible to prevent singing or oscillation? A. Well, only so far as it affected that particular test, and the notes are not sufficient to give you the exact condition under which the test was made. That is, as I read them now.

Q. 786. So the notes do show that you didn't prevent singing or oscillation, but they don't show what the conditions were. Now on page 50 under date of November 28, 1925 with reference to those entries, you testified that you determined the effect "on the gain, intermediate frequency gain, of the set by varying the voltage of those two tubes at once." Does the entry show what means were used for varying the voltage of the tubes? A. No, it doesn't.

Q. 787. And you don't recall how it was determined? A. I don't recall the exact means, except that it was, it must have been from the data, an adjustable means, so that values could be held constant while reading the instrument.

Q. 788. Well, the potentiometer hand operated would be such a means, wouldn't it? A. That's right.

Q. 789. Now from your testimony on page 182 I understand that in making these tests in which the gain was so held constant by some means, you supplied to the set, that is, to the intermediate frequency/portion of the set, energy at 83 kilocycles from a generator, which

generator was no part of the set, is that right? A. That's right.

Q. 790. At that time there was no signal coming into the set from outside and no energy coming into the set from any heterodyning oscillator, was there? A. Referring to the data on page 50?

Q. Yes. A. No, that had only the input from this test oscillator that we used in supplying the 83 kilocycles, as far as I can determine from the information here.

Q. 791. The first radio frequency amplifier tube was not being used, is that right? A. It wasn't being used to supply the set with the signal. I think that it was actually in the circuit, because otherwise the voltages on the other tubes would not have been correct, that is, all of the tubes were tied into a resistance network so that physically removing the tubes might have changed the actual voltage and current values for other tubes.

Q. 792. Do I understand that the energy from the separate generator, the 83 kilocycle generator, was fed into the modulator tube, and didn't go into the radio frequency amplifier? A. That's as I recall it.

Q. 793. Then of course there was no automatic gain control in those tests? A. Not functioning during those tests.

Q. 794. Now, then, on page 54, under date of December 2, 1925 you made the first entry that refers to automatic gain control. You said: "Int. freq. characteristic with automatic gain control hooked across 250 mmf. condenser in second filter, but not delivering minus C to  $I_1$  and  $I_2$ . Bias on  $I_1$  and  $I_2$  maintained constant at minus six volts." As I understand it, the purpose of that test or measurement was to determine whether or not the hooking on of the automatic gain control would alter the fidelity characteristics of the intermediate frequency circuits, which characteristics you had already determined, is that right?

A. That's correct, except for one point, and that is, that there was the hooking on of the input to the automatic gain control circuit.

Q. 795. That is the hooking on. A. Where we were going to obtain the energy to operate the automatic gain control circuit, and what effect obtaining that energy from different parts of the circuit would have on the frequency characteristic.

Q. 796. Now in the first place I understand that when the automatic gain control circuit was so hooked on across the 250 mmf. condenser and the measurements made, the automatic gain control was not delivering any controlling potential to the grids of the amplifying tubes. A. That's right.

Q. 797. That is, it wasn't functioning to automatically control? A. For this test.

Q. 798. Now I suppose that the measurements then made were to be compared with the measurements you had already made of the characteristics of the intermediate frequency circuits? A. The values should be relatively the same.

Q. 799. Well, is it correct for me to deduce from that that the tests previously made to determine the characteristics of the intermediate frequency circuits were made without any automatic control loaded on to those circuits at all? A. Yes, I think that is correct.

Q. 800. And so far as your notebooks show, this was the first time that the automatic volume control was connected on to the intermediate frequency circuits? A. Yes, this was the first test in which it was connected.

Q. 801. Now Mr. Philbin again, in Q. 623 used this sort of language. He said: "Opposite this page 54 there are various measurements and there is also a curve sheet attached to it. What was the automatic gain control that was employed in these measurements?" and you said:



"Well, that's the automatic gain control circuit", etc. Now, as a matter of fact, there wasn't any automatic gain control in the tests, that is, although the automatic gain control circuit was loaded on to the intermediate frequency circuits, there wasn't any automatic gain control?

A. That's right.

Q. 802. Then as I understand your testimony this hookup of the automatic gain control circuit across the condenser in the second filter was shown by the measurements to distort the characteristics of the intermediate frequency circuits, and was therefore abandoned, is that right? A. Yes, that's right.

Q. 803. And you substituted for it an arrangement for taking the energy out of the intermediate frequency circuits into the automatic volume control circuits, which arrangement is shown on Plaintiff's Exhibit 10 and comprises a third coil associated with the transformer between the last stage of intermediate frequency amplification and the second detector, is that right? A. That is correct.

Q. 804. On page 192 in answer to Q. 638 you referred to this separate coil arrangement and said: "That was the final solution of obtaining that input voltage." Did you mean that that was the immediate solution, or did you intend to say that that was the solution which was finally adopted and used in the 7A sets? A. That was the final solution which was used in this receiver and actually the connection of the condenser operated the automatic volume control, but this coil was found to be a more desirable method because it didn't react unfavorably upon the intermediate frequency characteristic.

Q. 805. Well, in your testimony on page 194 you said that by this arrangement "the adverse effect of connecting any automatic gain control circuit had been eliminated." Is that your present recollection? A. Yes.

Q. 806. Have you any knowledge or recollection of the fact that at a date subsequent to, we will say, January 1st, 1926, the input to the AVC amplifier was changed from the input to the second detector, to the output of the second detector? A. I don't quite get the question.

(Question repeated by the stenographer.)

A. I know at one time that we did take that input off the output of the second detector, that is, the input to the automatic gain control circuit, but as regards the January 1st date, I don't recall.

Q. 807. But you do have a recollection that at some later date, that is, a date later than the time when you used this third coil associated with the transformer between the last stage of intermediate frequency amplification and the second detector, that some time subsequent to that use the change was made to connect the AVC circuits to the output of the second detector? A. As I recall it that change was made prior to the time we adopted this coil, for the reason that if we could have used the output of our second detector the signal voltages would have been at a higher level at that point and we would have required less amplification in our automatic gain control circuit.

Q. 808. Well, in this Exhibit 10 that you referred to, illustrating the arrangement now under discussion, the AVC energy is taken off from the input side of the second detector, isn't it? A. That's correct, through coil L8.

Q. 809. And your recollection is that that arrangement came after another arrangement in which the energy for the AVC circuits was taken off of the output of the second detector? A. That is correct, that is my recollection.

Q. 810. And you arrive at that recollection, do you, by the process of reasoning somewhat as follows: That you would have used the connection from the output of the second detector if you could, because you would have

that much additional gain? A. That's right; rather, to modify that, we would have required less gain in our amplifier for automatic gain control, specifically, because the input would have been at higher level.

Q. 811. Well, however it is expressed, your thought was this: That if you could have used the output of the second detector it would have been better, therefore you conclude that you must have used that first and discarded it? A. That's right.

Q. 812. Well, now, in Exhibit 5, which is a schematic diagram of DDAC-2 radio receiver, the AVC energy is taken off, as I understand it, from the output of the second detector is that right? A. That's right.

Q. 813. Well, Mr. Scarr, Mr. Betts testified, I am referring to page 33 of the transcript, as follows: "Q. 118. You have stated that the December 30, 1925, receiver, had automatic volume control, utilizing an amplifier tube and a rectifier tube and connected to the input of the second detector. Will you tell us whether that same arrangement was used in each of the succeeding receivers? A. At a later date the input to the AVC amplifier was changed from the input to the second detector, to the output of the second detector. This was done as shown in the drawing dated April 24, 1926, and as shown in the DDAC-2 diagram offered as Plaintiff's Exhibit 5. Q. 119. Was that the same arrangement as shown in Plaintiff's Exhibit 5 employed in all of the succeeding receivers? A. Yes." Now have you any reason to doubt that Mr. Betts was right when he testified to that? A. No, I haven't.

Q. 814. That is, Mr. Betts' testimony is more convincing to you on that point than your own recollection? A. Well, that helps me fix a date. The thing is this, though: I am not sure that we had not in the preliminary stages considered the use of the output of the



second detector to feed the gain control system, and came to the conclusion that using the coil in the input circuit would be a better arrangement; I don't think that that precluded possible setups later, using the arrangement once discarded. I don't recall.

Q. 815. That is, you think it might be possible, but you don't recall? A. I don't recall.

Q. 816. Well, now, Mr. Betts went on to say when he was asked: "Q. 120. Why did you change the AVC connection from the input of the second detector to the output of the second detector?" he answered "A. The reason was two-fold. One was to make use of the additional gain to be derived from the amplifying action of the set and the detector; and the second was to reduce the effect on the intermediate frequency characteristic, inasmuch as we found a reaction back from the AVC amplifier when connected across the input of the detector tube." Now, his testimony if I correctly understand it was that the arrangement by which the energy was taken from the input of the detector tube did create distortion of the characteristics, and was superseded by the later arrangement in which the energy was taken from the output? A. The connection across the condenser in that filter circuit certainly did react on the frequency characteristic. It is my recollection, though, that the coil method of pickup was satisfactory. I don't know; my experience with the set didn't carry through to the completion of the development, so that I don't know which form was finally adopted.

Q. 817. That is, you would subordinate your recollection to Mr. Betts' testimony about that, wouldn't you? A. Well, I think I would.

Q. 818. Now I wish you would look with me at page 194 of the testimony. You were referring there to a curve dated December 19, 1925, showing the fidelity char-

acteristic of the intermediate frequency system, and then Mr. Philbin asked: "Then what did you do, as shown by your notebook?" and you started saying that the next investigation "was to proportion the constants of the gain control circuits" and said: "These particular tests were started in—" and you never did finish that sentence so far as I can find, that is, you were diverted by a discussion of the selector arrangement. I am interested to know when, so far as your notes show, you did begin tests or measurements as to the constants of the gain control circuits. A. Well, that sentence was really taken up again in question 648 on page 199. The answer to that is: "Well on pages 88 and 89, dated December 23, 1925, we began to investigate the optimum values."

(Whereupon, at 12.40 P. M. on Monday, September 16, 1935, an adjournment was taken for lunch until 2.15 P.M.).

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Monday, September 16, 1935, 2.30 P. M.

Q. 819. In the question 627: "That is, one side of the condenser was connected to the grid of an additional intermediate transformer tube", shouldn't that be "amplifier tube"? A. I think it should be intermediate amplifier tube, although we had a little previously said that what we meant was the tube and the circuits surrounding it. But then we speak of the grid.

Q. 820. On page 190, down a little below the middle of the page: "On that particular investigation we changed the 250 micromicrofarads to 250 micromicrofarads"? A. That is incorrect. It should be 200.

Q. 821. Were you charged during this experimental work with any responsibility for the design of the automatic volume control circuits themselves? A. Yes, I had a certain amount of responsibility for that. My primary

activity was in making tests, but the matter of design was the subject of concerted action among the members of the group that were working on it.

Q. 822. Now will you please look at Exhibit 3-A, dated January 2, 1926, in which the first sentence is: "Suggestion for DC amplifier, wherein the required A, B and C batteries are furnished by one high tension source, battery or rectified A. C." (Witness examines exhibit) I assume that that refers, or that suggestion referred back to some automatic volume control system in which the A, B and C batteries are not furnished from a single source. Do you know what previous automatic volume control system it did refer to, and may it not refresh your recollection to refer to the testimony of Mr. Betts on page 78 of the record, where he said that the previous form of automatic gain control he had in mind was "That of the earliest type requiring separate batteries for the control tube." A. Well, I agree with that testimony, that is, that the automatic gain control circuit that preceded this arrangement was supplied from one source, and I rather imagine that the previous patent is; I don't recall what it was.

Q. 823. Such an arrangement employing a separate battery 17 is shown in Figure 1 of the Friis patent 1,675,848 (handing patent to witness)? A. Yes.

Q. 824. Now as I understand it in the system that was finally developed and used in the 7A receiver, the AVC arrangement differed from Friis in this, that instead of using a separate battery in the AVC circuits the potential required there was derived from a common source and was secured by properly connecting in series the filaments of the other tubes in the set, is that right? A. That is correct, yes.

Q. 825. On page 195 and following you testified that "We determined that it would be desirable to make the characteristic of that transformer (referring to the trans-



former through which the energy was taken off from the intermediate frequency circuits into the automatic volume control circuits) more peaked or to cover a narrower frequency band than did the intermediate frequency amplifying system, and this particular entry in the fifth column of page 87 showed the effect on that transformer of tuning it with a pigtail condenser," A. The transformer I was referring to in that connection was the one between the fourth intermediate tube and the control tube, rather than the one which took the energy into the automatic gain control system. This transformer (indicating.)

Q. 826. That is, you are referring to the transformer that is marked in pencil "L13"? A. L13, that's right.

Q. 827. On Exhibit 10, and which is located between the intermediate frequency amplifier and the AVC rectifier? A. That's right.

Q. 828. And that, as I understand it, was put in for the purpose of making the automatic frequency control more selective than the intermediate circuits, is that right? A. It was to make the automatic gain control more selective, that's right.

Q. 829. The arrangement you testified about had the same purpose, did it not, as the resonant circuit 13,14 connected in shunt to the output circuit of the amplifier detector, as shown in Figure 1 of Friis patent 1,675,848, and described in lines 53 and following, at page 2 of the specification of that patent? A. (Examining specification) It apparently had somewhat the same action, although in reading this I do not see that it covers a more selective circuit than the circuit which passed the signal frequency.

Q. 830. Well, Mr. Friis in his patent on page 1, lines 59 and 60 refers to separating the carrier waves from the side waves and again on page 4, lines 72 and following, he speaks of the possibility "to separate the car-

rier more completely from its accompanying side frequency, and thereby to secure more exact regulation", and I am informed that that was the purpose and effect of his resonant circuit 13, 14, is that right?

Mr. Philbin: Do you mean is it right that you are so informed?

Mr. Davis: Is the assumption sound or is the information correct?

A. It would seem that it is.

Q. 831. Well, that was the purpose and effect of this more selective transformer arrangement that you testified about, wasn't it? A. Yes, that's right.

Q. 832. As I understand it, that interposed carrier selector was so designed that it passed 83 kilocycles and cut off quite sharply anything above 84 and below 82 kilocycles, is that right? A. Yes, that is substantially where we cut it off.

Q. 833. And the 83 kilocycles was the frequency of the intermediate carrier, was it not? A. Yes, that's right.

Q. 834. And the result was, as I understand it, that as the intermediate carrier frequency departed from 83 kilocycles and when it went below 82 kilocycles or above 84 kilocycles, the automatic gain control wouldn't function, is that right? A. Yes, it would function to bring up the gain.

Q. 835. Well, that's just the thing I want to get straightened out in my own mind. In your testimony at pages 196 and 197 you said: "changing the carrier frequency, a matter of 5,000 cycles away from 83 kilocycles, would not have caused the automatic gain control to function, that is, no change in the gain". A. That was predicated, though, on the fact that if we had not had some sort of device like this, which is in the beginning of that answer. It starts out: "Well, if we had

not had some sort of device like this, the gain control circuit would have operated on a characteristic determined by the characteristic of the intermediate frequency circuits, in other words, changing the carrier frequency, a matter of 5,000 cycles away from 83 kilocycles, would not have caused the automatic gain control to function.

Q. 836. You are right about that. It seems to me that I would have said the thing this way: I am putting it this way, to see if I understand what you had in mind; that without this device, the control potential applied to the grids of the amplifier tubes would have been held constant, even though the frequency of the carrier wave departed substantially from 83 kilocycles, and what you wanted was some arrangement in which the gain control potential would not remain constant upon such departure, but would be reduced relatively on such departure, thereby holding up the gain; in other words, due to the selectivity of the radio frequency portion of the set, the gain needed to be increased sooner than it would have been if it had been connected to operate on the characteristic of the intermediate frequency amplifier, that is, if there had not been any selector between the intermediate frequency amplifier and the gain control? A. A more selective system for the automatic gain control than for the intermediate frequency amplifier. With that arrangement you could cause the automatic gain control to function to increase the gain to compensate for slight displacements of the carrier with respect to the frequency to which the radio circuits were tuned.

Q. 837. And the effect was to decrease the amount of control and thereby permit increase of amplification as you departed from the 83 kilocycles? A. Well, I don't quite understand what you mean by decreasing the amount of control. You really didn't decrease the amount



of control. It was always controlled. You caused it simply to operate on a more peaked characteristic, that is, you caused it to operate sooner.

Q. 838. Probably the word control is what confuses me. I will put it this way, in the intermediate frequency circuits, you had an arrangement which would pass effectively a band of how many kilocycles on each side of 83? A. Well, about 5,000 out of a variation limit which we thought was allowable.

Q. 839. And then you wanted the passage to the automatic gain control to be more selective and a narrower door than that? A. That's right, yes.

Q. 840. You wanted that to pass effectively only 83 kilocycles down to 82 and up to 84? A. That's right, yes.

Q. 841. Well, now, take a variation as you did, we will say of 5,000 cycles from the 83 kilocycles. A. It would begin to be shnt off, it would go off rather quickly.

Q. 842. And the result of that would be that less controlling potential would be put on the grids? A. That's right.

Q. 843. So that the negative bias of the grids would be less negative? A. That's right.

Q. 844. And the amplification would be greater? A. That's right.

Q. 845. And that had the effect, I think you have already said (if you haven't, correct me) that had the effect to more effectively separate the carrier wave from the side waves before the energy was passed to the automatic volume control? A. Yes, that was one of the reasons for doing that, that is true.

Q. 846. Well, as I understand it, Mr. Scarr, the effect of such an arrangement as this would be that whenever the intermediate frequency fell below 82 kilocycles or rose above 84 kilocycles the effect of the automatic volume control to reduce amplification would be cut off in

the proportions that would be indicated by your curve on page 87, is that right? A. Well, that's one way of looking at it.

Q. 847. On page 209, in answer to Q 693, your attention was directed to Plaintiff's Exhibit 12, and you were asked "Was the receiver which is shown in that circuit diagram in existence on or before January 14, 1926?" and you answered: "Yes, it was in existence before December 15th." When you speak of the receiver being in existence, you mean only, do you not, that the laboratory model upon which all of these changes were made was at one time connected in that particular way, that is, you do not mean that there was any receiver separate from this laboratory model which was set up and remained in existence without change? A. That's correct, I don't mean that there was a separate receiver.

Q. 848. And does the same comment apply to your answer to Q. 706 on page 211? A. That has to do with Exhibit 14. The same comment applies there.

Q. 849. The testimony heretofore taken shows that the so-called firing order of the tubes was repeatedly changed over some considerable period of time in 1926 and 1927. Did you have anything to do with that? A. The earlier stages of it, yes.

Q. 850. Am I correct in understanding that the repeated rearrangement of the firing order of the tubes was part of the development work that grew out of Mr. Betts' suggestion recorded under date of January 2, 1926 in Exhibit 3-A that a system should be developed "wherein the required A, B and C batteries are furnished by one high tension source, battery or rectified AC"? A. Yes; possibly we might say that this suggestion may have grown out of that. I don't know that this suggestion occurred before the starting of the changing of the firing order. The firing order changes may have been com-

pleted first, although it was all towards the same general purpose.

Q. 851. And it was all done to develop a satisfactory substitute for the use of a separate battery as in the Friis patent? A. That's correct.

Q. 852. And all the development work that you did leading up to the 7-A receivers and the 7-A receivers themselves, so far as you know, all followed the Friis plan of interposing between the automatic volume control and the intermediate frequency circuits a selector that was more selective than the intermediate frequency circuits? A. Yes.

Q. 853. Am I correct in understanding that this repeated rearrangement of the firing order of the tubes had at least two purposes, one was to eliminate oscillating conditions and the other was to give a desirable frequency characteristic to the circuits? A. Well, it didn't have such a great effect on the frequency characteristic, except possibly through the elimination of oscillating conditions. Another reason for that was to obtain the desired voltages with the minimum voltage of rectified supply current and also we desired to keep the maximum voltage above ground to as low a value as possible, and other considerations like that.

Q. 854. Including, of course, I assume, the desirability of getting a suitable potential to take the place of the separate battery potential of Friis? A. Of course that was the primary objective, but the others were subordinate to it and were required to meet the other requirements of the set.

Q. 855. As I understand, Mr. Scarr, your notebook that you put in evidence here, does not contain any record of any measurement made with the automatic volume control operating, is that right? A. Yes, it does on the curves attached to page 98 and the data on pages



98 and 99, the automatic gain control was operating to maintain the output more or less constant, depending upon the value of the automatic gain control used.

Q. 856. And does the record show the use of different resistances and then you measured the automatic gain control with different resistances? A. That's right.

Q. 857. Was the input energy in all those tests the same? A. The input energy varied from a low value to a higher value in each test.

Q. 858. And over the same range in each successive test? A. Substantially the same range. A better curve extended over a greater range than any of the others.

Q. 859. How about the frequency of the input energy, was that maintained constant? A. The frequency was maintained constant.

Q. 860. Does the book show what the input energy was derived from and was it a separate generator, or what? A. Well, the book doesn't mention that directly, but this data refers to the calibration of the detector 101 which is covered on page 96, and the curve attached thereto, in which the statement is made that calibration of the detector 101 for 83 kilocycles, so that—. That would be calibration for 83 kilocycles, anyway, because that was at the output end of the amplifier. Coming back to the question, there is no indication in the book as to how the input was made.

Q. 861. Does your notebook show how sharply selective the radio frequency circuits were? A. Not in the part of the book in which I am responsible for making entries.

Q. 862. What are the ordinates in the curves attached to page 98? A. Well, I believe I testified previously that those ordinates were volts but that's not correct. On page 201 of the testimony in Q. 655 I was asked to point out what the ordinates represent and I replied that the

ordinates represent the output of the set, I don't know which of these figures are plotted, but we took the output current of the tubes through a fixed resistance and I believe that was what was plotted in the ordinates, but since that time I have given more careful consideration to the curves and I find which of the data is plotted and the ordinates represent the deflection of the meter used in the output circuits of this detector 101, for which a calibration is shown on the curve attached to page 96.

Q. 863. Was this detector tube in the set? A. Yes.

Mr. Langley: Second detector?

The Witness: Second detector, yes.

Q. 864. The 7-A receivers are uni-controlled receivers? A. "Uni-" as regards tuning.

Q. 865. Do you know at what stage of the development work the tuning was effected by uni-control? A. That occurred quite early in the development. I think that was really about the first thing that we investigated here, the design of the oscillator and some of the earlier circuits, to establish whether that would be possible or not.

Q. 866. Your recollection is that as far as this development of this receiver which finally eventuated into 7-A was concerned, it was planned from the beginning to make it a uni-controlled circuit? A. Uni-controlled, yes.

Q. 867. You spoke about talking with Mr. Friis. I'd like to have you throw your mind back again, if you can, and say whether you can recall whether Mr. Friis talked only with you or with the other engineers? A. As I recall, he talked with a group of us, all in the same department there. I don't recall just who was in the group at the time, probably Mr. Anderson, Betts and myself; perhaps Fischer, I am not sure.

*Re-direct examination by Mr. Philbin:*

Q. 868. Did you talk about automatic gain control or

automatic volume control with a Mr. Affel or a Mr. Heising? A. No.

Q. 869. The expression: "automatic gain control" has been used and also "automatic volume control". Have you used those two expressions interchangeably or have you distinguished between them in your answers? A. The way I have used them in my testimony has been interchangeably.

Q. 870. You were asked about pages 48 and 49 of your notebook, dated November 27, 1925, with respect to some singing or oscillating condition that was encountered in some arrangement. Do you recall what that particular arrangement was in which you encountered this singing or oscillating condition? A. No, I do not.

Q. 871. Did you have any difficulty with singing or oscillations in the receivers or circuits that were thereafter developed and used? A. We had no trouble particularly with them. Apparently this was just some particular condition that allowed that to occur. It wasn't a condition frequently encountered, or anything like that.

Q. 872. You spoke of distortion. Does that mean a departure from fidelity? A. That's correct, yes.

Q. 873. Is any departure from fidelity spoken of as distortion? A. In general, yes.

Q. 874. Do you know of any commercial circuits employed for handling speech signals in which there is not distortion, that is, a departure from absolute fidelity? A. Well, I think that as far as I know there are no circuits having absolute fidelity.

Q. 875. Now in one of these oscillator arrangements of this receiver the automatic volume control was connected to a condenser, a 250 microfarad condenser, and I understood you to testify that there was some distortion under that condition, and then it was changed to a connection to a coil. Can you state about how much distortion there



was when the connection was to the condenser? A. Well, the connection to the condenser, on one side there was a valley.

Q. 876. To what are you referring now? A. This curve attached to page 55. On the left-hand side of that curve there was a valley about 4 TU down from the peak value, meaning that there was a variation up to 5,000 cycles of about 4 TU which, while it was not as perfect as some previous curves we had, is fairly good.

Q. 877. It is a departure of about 5%? A. Yes. 4 TU out of 80 would be about 5%, valued at 5,000 cycles.

Q. 878. How did such a departure, that is, a distortion of about 5%, compare with broadcast receivers as of 1925, with which you are familiar? A. Well, I think it was as good, if not better, than most of the receivers of that day.

Q. 879. When you changed to the condenser, as distinguished from the receiver, you got less distortion, as I understand it; about how much less? A. (examining book) With the coil connection it was reduced to approximately two transmission units at 5,000 cycles, so it was reduced at least by half.

Q. 880. Now referring to the typewritten testimony, page 199, about eight lines down, I find references to pages 88 and 89, dated December 23, 1925, is that correct? A. Yes, I think it is.

Q. 881. Do the results of the measurements, as shown on those pages, 88 and 89, disclose that automatic volume control circuits were then being actually operated? A. Well, there is a reference made to the gain control rectifier and various values of the resistance, here's the AVC resistance, so that the indication is that we certainly had an automatic gain control circuit at that time.

Q. 882. Referring to page 98 of your notebook and the vertical line or ordinate, do the values on it show

the deflection which represented the output in volts or millivolts of the receiver? A. Yes.

By Mr. Davis:

Q. 883. In this arrangement of the filaments or cathodes of the tubes in series which was worked out as a substitute for the Friis arrangement in which a separate battery was used in the automatic gain control circuit, it is true, is it not, that no two cathodes in the set were at the same potential? A. As regards the smaller tubes, that is correct. There were some power tubes and the rectifier tubes in which there was the same attachment, but as regards the smaller tubes, they were not.

Q. 884. That means the intermediate amplifier tubes to which the controlling potential was applied, and also the automatic gain control tubes? A. Were at different potentials, that's right.

Q. 885. They had to be at different potentials since they were all in series, isn't that so? A. That's right.

UNITED STATES DISTRICT COURT,  
DISTRICT OF DELAWARE.

RCA VICTOR COMPANY, INC.,  
Plaintiff,  
*vs.*  
HAZELTINE CORPORATION,  
Defendant.

IN EQUITY  
No. 1071.

STIPULATION

It Is Stipulated and Agreed for the purposes of this suit, subject to correction should error appear, that if Benny O. Browne were duly called as a witness by plaintiff he would give the following testimony, viz.:

That during 1926 and 1927 he was employed by the Bell Telephone Laboratories, Inc., as a mechanical designer, that he has examined plaintiff's exhibits 4-D, 5, 6-B, 7, 8-A and 8-C, dated March, 1926 to July 15, 1927, which are schematic diagrams for the so called DDAC-1, 2, 3, 4, and 5 radio receivers, that the words "See later issue B.O.B." on exhibits 4-D and 5, the words "B. O. Browne Room 193-B See new issue" on exhibit 6-B, and the words "B. O. Browne Room 193-B" on exhibits 7, 8-A and 8-C were written by him on such exhibits on or about the last date on each of said exhibits, respectively, and that he believes the circuit diagrams on each of said exhibits were there at the time that he wrote said words thereon.

It is further stipulated that the aforesaid matters as to which said Browne would testify shall have the



same force and effect, subject to any objections which may be made with respect to relevancy and materiality, as if said Browne had duly testified to the same before trial, under oath and subject to cross examination, in accordance with Equity Rule 47 and pursuant to "Notice of Taking Depositions" dated January 3, 1935, herein.

October 7, 1935.

STEPHEN H. PHILBIN,  
Counsel for Plaintiff,  
PENNIE, DAVIS, MARVIN, &  
EDMONDS,  
Counsel for Defendant.

### **FINDINGS OF FACTS AND CONCLUSIONS OF LAW** (Filed April 17, 1939)

This matter came on to be heard on the bill of complaint of plaintiff, and the answer, and the court was advised that one of the defenses to be relied upon by the defendant was that the re-issue patent in litigation was invalid because it was not issued in accordance with the provisions of Section 4916 of the Revised Statutes (35 U. S. C. A. Section 64), and the Court, being of the opinion that this phase of the case could and should be considered in advance of the more complicated matter of infringement and validity of the patent, in accordance with the provision of Subdivision b of Rule 42 of the Rules of Civil Procedure, and counsel for both sides having complied with the wishes of the court and submitted proof directed to this issue only, with the understanding that all other matters are to be held in abeyance pending the final determination of this issue if an appeal is taken.

Counsel for both parties have agreed to the following findings of facts:

#### **FINDINGS OF FACT**

1. The application for the original patent of which the patent in suit is a re-issue, was filed on November 13th, 1930, and issued as original Patent No. 1,879,863, on September 27, 1932. The file history of this patent (Defendant's Exhibit "B") evidences careful preparation and prosecution of the application and careful efforts to define the invention by the respective claims by applicant's solicitors and that the claims solicited were allowed by the Examiner of the Patent Office and that the claims of the patent as allowed by the Examiner of the Patent Office were accepted by the patentee and his solicitors.

2. On August 6th, 1934, Judge Galston in the United States District Court for the Eastern District of New York, found claims 1, 5, 6, and 10 of the patent to be invalid for the reasons set forth in his opinion reported in 7 Fed. Sup. 908. The decree of the District Court dismissing the bill of complaint was entered pursuant thereto on September 18, 1934.

An appeal from this decree was taken by plaintiff, Hazeltine Corporation on September 21, 1934.

3. On September 26, 1934, application for re-issue of the original Wheeler Patent, No. 1,879,863, was filed pursuant to Section 4916 R. S. (U.S.C. Title 35, Section 64), which application for re-issue was accompanied by the oath of the applicant in accordance with the requirement of Rule 87 D of the United States Patent Office. This oath asserted that the re-issue was necessitated because of "defect or insufficiency" in the original patent, which arose from "inadvertance, accident or mistake and without any fraudulent or deceptive intentions on his part". On July 19, 1935, the Patent Office held this oath "insufficient since it merely alleges that the patent is insufficient and inoperative by reason of the failure to make certain claims, and that the error arose through inadvertance, accident or mistake, but does not specify the errors which constitute inadvertance, accident or mistake."

4. The appeal to the Circuit Court of Appeals of the Second Circuit was prosecuted and that Court on July 29, 1935, filed its opinion reported in 79 Fed. 2nd 329.

5. On August 31, 1935, the applicant, Wheeler, executed a new oath which was filed with the Patent Office in connection with his application for re-issue on September 3, 1935, in which he recited that the alleged errors of his original patent, which formed the basis of his



application for re-issue thereof, and which arose from inadvertance, accident or mistake, and without fraudulent or deceptive intentions on his part, were as follows:

"That on January 3, 1926, he completed and successfully operated a radio receiver which included an amplifier of modulated-carrier signals and a system for automatically controlling the amplification thereof; that an application for patent was filed by the attorneys for Hazeltine Corporation July 7, 1927, Serial No. 203,879; that essentially and except for minor and unimportant differences the circuit arrangement used in said receiver for automatically controlling the amplification is illustrated in Figs. 1 and 3 of said original application filed July 7, 1927 (which are Figs. 1 and 3 of the present application for re-issue) and specific circuit constants for said automatic amplification control circuit are given in said original application (original patent No. 1,879,863, p3, lines 23-38 inclusive and present application for re-issue p7, lines 16-19 inclusive); that said original application and patent No. 1,879,863 granted thereon also describes essentially except for minor unimportant differences the elements of said radio receiver with which said automatic amplification control was used and also describes the mode of operation of the specific amplification control system which was disclosed; that additionally said original application and the patent No. 1,879,863 discloses among other things other circuits which might be employed using automatic amplification control; that although he was not versed in the construction of patent claims, the claims finally allowed (and subsequently issued in said patent No. 1,879,863) were brought to his attention by the attorneys for Hazeltine Corporation before the patent issued; that they then seemed to him to define and protect his automatic amplification control invention which had been embodied by him in said radio receiver;

that it was not until Judge Galston so held that he became apprised that certain of these claims did not define his invention and did not distinguish from what others had done and that such patent did not have sufficient and proper claims to protect his invention; that this opinion of Judge Galston was rendered August 6, 1934; that as promptly thereafter as possible a revision of the specification and claims of said patent was undertaken in order to correct the error that had been made; that on September 26, 1934, the present application for re-issue was made; that subsequently, namely on July 29, 1935, the Court of Appeals for the Second Circuit in an opinion by Judge Learned Hand affirmed said decision of Judge Galston; that the amendment to the specification and claims which are submitted herewith have been made in the light also of said opinion of the Court of Appeals so as to assure that the claims in the re-issue application accurately defined what he had invented and disclosed and had thought was protected by the original patent."

6. The evidence in this case establishes that the applicant, Wheeler, who executed the oaths, prior to the issuance of his original patent had had experience as a patent expert in radio patent litigation; having testified in radio patent suits regarding patents and so-called prior art, including a case entitled *Lester L. Jones v. Freed-Eisman Radio Corporation*, in April, 1929, at which time he understood or believed that he understood radio patents; also in the case of *Hazeltine Corporation v. American Bosch Magneto Corporation* in the United States District Court, Southern Division, in or about November, 1930, in which he testified that he was generally familiar with patents, particularly in the radio art; that he had studied a number of patents prior to 1930 and had had some experience with claims; and that prior

to 1931 he had applied for a number of patents pertaining to the radio art, of which 22 issued as patents assigned to Hazeltine Corporation and all of which had been prepared and prosecuted by the solicitors for plaintiff Hazeltine Corporation who solicited the original and re-issue patents.

7. This oath was accepted by the Patent Office and the re-issue patent issued.

8. During the prosecution of the application for the original patent 1,879,863, in which original claims 1, 5, 6 and 10, subsequently declared to be invalid, were allowed by the Patent Office, the Patent Office did not cite as a reference or call the applicant's attention to Affel patent 1,574,780 or the Heising patent 1,687,245 or the Bjorson patent 1,666,676, which were among the patents relied upon by the District Court for the Eastern District of New York and by the Second Circuit Court of Appeals in the case of Hazeltine Corporation v. Benjamin Abrams, et al., and the applicant was not aware of either of those patents until about the time of filing the answer in the Abrams case about May, 1934.

9. In the Patent Office communication of December 13, 1934, in the re-issue application, the Examiner noted the decision of Judge Galston in the case of Hazeltine v. Abrams et al. In the communication to the Patent Office filed September 3, 1935, which was accompanied by the supplemental oath, the solicitors and applicant directed the Examiner's attention to the fact that Judge Galston's opinion had been affirmed by the Second Circuit Court of Appeals and noted that the Examiner had had a copy of the Circuit Court of Appeals opinion.

10. Hazeltine Corporation, the owner of the Wheeler re-issue patent in suit, was organized early in 1924 and since that time has been engaged exclusively in designing



and developing radio and television apparatus and conducting research in connection therewith and patenting inventions resulting therefrom and in rendering engineering services exclusively (with but few exceptions) to its licensees under its patents. This includes designing and testing apparatus for the licensed manufacturers and helping them in their manufacturing problems. For this purpose it maintains three research laboratories at an approximate cost of \$100,000 per year, employing a number of radio engineers.

11. Hazeltine Corporation now owns approximately 200 issued United States patents of which approximately 43 were issued during the last three years.

12. Its sole revenues are the royalties paid it by its licensees under its patents.

13. Until about three years ago and with few exceptions, all of its patent work was done by the firm of Pennie, Davis, Marvin and Edmonds, one or more members of which as early as 1925 had had considerable experience in soliciting and litigating patents in the radio art and which firm maintained a staff of individuals, including a Mr. Baldwin Guild, who were skilled and expert in the radio art and who devoted their entire time to radio matters.

14. The patentee, Mr. Wheeler, acting for Hazeltine Corporation throughout, made a complete disclosure of his invention to Mr. Baldwin Guild and put the drafting of the specifications and claims of his original application for patent in his hands. The application as prepared by Mr. Guild was submitted to Mr. Wheeler and examined by Mr. Wheeler both as to specifications and claims and approved by Mr. Wheeler prior to filing.

15. Mr. Wheeler was kept advised of the progress of

the application in the Patent Office and after each action by the Examiner reviewed the action and assisted Mr. Guild in studying the prior art references cited by the Patent Office, in pointing out differences between his invention and the disclosures of the prior art, and between the elements of his claims and those disclosures.

16. Mr. Wheeler understood that the claims are required to correctly define the invention of the patent and to differentiate from the patents of the prior art.

17. When the application was allowed, Mr. Wheeler examined the specifications and claims to determine whether the specification was an accurate description of and whether the claims properly defined his invention, and found them acceptable and authorized the issuance of the patent.

18. As originally filed on July 7, 1927, the Wheeler application Serial No. 203,879 contained in its specification a full, clear and exact description of the system of automatic volume control which Wheeler had theretofore reduced to practice in operative radio receivers, which description was sufficient to enable others skilled in the art to construct and use such receivers; and the divisional application filed November 13, 1930, and the application for re-issue filed September 26, 1934, likewise contained in their specifications such full, clear and exact descriptions of Wheeler's automatic volume control system.

19. The application for the original patent and the application for the re-issue were prepared and prosecuted by Mr. Baldwin Guild, a patent solicitor in the offices of Pennie, Davis, Marvin and Edmonds, in close collaboration with the inventor, who consulted with the solicitor with respect to each communication from the Patent Office and assisted him to understand the technical sub-

stance of the prior disclosures cited by the Patent Office, to compare them with the disclosure of Wheeler's automatic volume control system in the specification of the patent application and to define in the claims the Wheeler invention so as to distinguish it from the prior patents and publications and prior knowledge as the inventor understood them, and this was done honestly without fraudulent or deceptive intention, and without intending to claim as Wheeler's invention or discovery more than he had a right to claim as new.

#### CONCLUSIONS OF LAW

1. The re-issue patent was legally issued in accordance with the provisions of Section 64, Title 35, U. S. C. A.

2. The term "inadvertence" as used in this statute has been given a liberal construction for the purpose of protecting the interest of the patentee in his invention. The errors here were not made with fraudulent or deceptive intention. It is clear that the patentee made a complete disclosure to the Patent Office in his application for a re-issue, and that this matter was carefully considered by that office before the allowance of the reissue patent.

"Inadvertence is a word of broad meaning. The act of the patentee, through his solicitor, in drafting or accepting claims not commensurate with the invention, may be considered a mistake of law or a mistake of fact. In the typical case it is rather of the latter character, and is made because he does not appreciate the part which certain elements play in the operation and the value of the device described; but whether we call it a mistake of law or fact, it cannot very well escape the appellation 'inadvertent', unless, in truth, it is considered and deliberate. *Leggett v. Avery*, 101 U. S. 256; *Yale*



v. Berkshire, 135 U. S. 342; Grand Rapids Co. v. Baker (C. C. A. 6) 216 Fed. 341, 351. This latter question—whether the error really was inadvertent or was deliberate—is primarily committed to the Patent Office for its decision. If the Patent Office, by general rule or by action in a particular case, should hear conflicting evidence upon that question and decide it, the courts would not lightly review that decision. None the less does this result follow when the Patent Office sees fit to accept and act upon an ex parte affidavit. It is only when other parts of the record (as the former, deliberate abandonment of the broader claim) conclusively show that the error was not inadvertent that there seems to be reason for disregarding the prima facie case made out by the Patent Office decision."

American Automotoneer Co. v. Porter, 232 Fed. 456, 460 (C. C. A. 6).

Van Kannel Revolving Door & Window Co. vs. Winton Hotel Co., 276 Fed. 234 (C. C. A. 6).

Fehr vs. Activated Sludge, Inc., 84 Fed. (2d) 948 (C. C. A. 7).

(Signed) Arthur F. Lederle,  
District Judge.

**FINDINGS OF FACT AND CONCLUSIONS OF LAW**

(Filed December 26, 1939)

1.

The Plaintiff is a corporation organized under the laws of the State of Delaware. The Defendant is a corporation organized under the laws of the State of Michigan.

2.

Plaintiff is the sole owner of a United States Letter Patent reissued October 29, 1935, numbered Reissue 19744. The original patent No. 1,879,863, dated September 27, 1932, is a division of Serial No. 203,879, dated July 7, 1927.

3.

The Defendant is engaged in the manufacture and sale of radios. During the period between the granting of the reissue patent and the filing of this suit, March 8, 1938, the defendant corporation made, used, and sold radio receiving apparatus known as Models 175 and 178.

4.

It is the claim of the Plaintiff that the two models mentioned embody the invention described and claimed in the Wheeler reissue patent 19,744 and particularly claims 1, 2, 3, 4, 5, 9, 10, 11, 12, and 13, thereof, and that Model 175 also embodies the invention claimed in claims 6 and 7 of said patent, and seeks an injunction to restrain further manufacture of such receiving sets, and an accounting for damages sustained.

5.

Harold A. Wheeler, the patentee, prior to 1924, built

and operated his own transmitting and receiving radio station, and invented a radio circuit and has made other inventions in the radio field. Since 1930 he has been in charge of the research laboratory of Hazeltine Corporation. In the fall of 1925, Wheeler was 22 years of age, had graduated from the George Washington University, with a degree of B. S. in physics, and was a post-graduate student in physics at Johns Hopkins University and had devoted some time to laboratory work and related studies in the radio field for the Hazeltine Corporation.

## 6.

In July of 1925 Wheeler was aware of a defect in radio broadcast reception known as "blasting". As a radio broadcast receiver was tuned from station to station, the less powerful or more distant stations would sound faint; and when the receiver was adjusted to give normally loud sound for such a weak station, a nearby or powerful station would produce an extremely loud and unpleasant sound. This was the defect known as "blasting". It had long been known that radio broadcasting stations, except those very near the receiver, will deliver signals (programs) that do not remain constant in intensity from time to time, but go from relatively strong signals to very weak signals. This effect, due to atmospheric conditions, is known as "fading". These defects, both manifested in undesired variations of loudness, would be overcome by a satisfactory system for automatically controlling the volume of sound produced by the signal so that it would be held substantially constant. Wheeler undertook to develop such a system, beginning in July of 1925.

## 7.

Other radio engineers were familiar with this same problem, and work was being carried on in many lab-



oratories seeking to remedy this defect. In spite of his youth, Wheeler gave evidence of inventive genius in this field, and on December 17, 1925, he made an entry in his notebook proposing to use a diode with a high resistance (high in relation to the internal resistance of the diode), in its output circuit as a rectifier for developing the automatic volume control potential. He proposed to impress on the diode, the same highly amplified carrier frequency signal potential that was supplied to the signal detector (about 10 or 12 volts), directly from the applied carrier voltage. During the period of the Christmas holidays in December, 1925, he built an experimental radio receiver in accordance with this design and completed it some time shortly prior to January 2, 1926.

## 8.

At that time triodes were universally used for detectors, as well as amplifiers. Although Wheeler realized that a triode rectifier for automatic volume control had to have a critical balance of its B and C battery voltages (a requirement not present in signal detection), he at first decided to employ in his experimental receiver a triode for simultaneous detection and rectification for control purposes.

## 9.

The experimental receiver was a superheterodyne receiver in which the signal voltage was combined with a local oscillation to produce an intermediate frequency, as is characteristic of superheterodyne receivers. The signal voltage was selected in an intermediate-frequency amplifier and was amplified to approximately ten volts, which was high enough for automatic volume control purposes. In this first form of the receiver the signal voltage was rectified by a triode rectifier for both signal purposes and automatic volume control purposes. The rectifier was coupled to the amplifier by means no more

selective than the amplifier. The direct-current potential resulting from this rectification was passed back to the grid of the amplifier over a direct-current connection which included a time-constant filter which prevented the modulation fluctuations in the rectified potential from reaching the amplifier grid. The apparatus operated satisfactorily as a radio receiver, but not satisfactorily for automatic volume control purposes. With the limited amount of time and facilities available to Wheeler he was unable at that time to make the triode automatic volume control system operate.

## 10.

Wheeler then changed the receiver by eliminating a triode rectifier with its separate batteries which had to be critically adjusted and used the two-electrode (diode rectifier), with high resistance in its external circuit which he had devised on December 17, 1925. After this change, on or just prior to January 2, 1926, the operation of the automatic volume control was successful, and it was demonstrated to a number of Wheeler's friends on January 3, 1926.

## 11.

Mr. Wheeler kept a notebook and made regular entries therein of his progress in developing his invention and from time to time had other persons sign his notebook as witnesses.

## 12.

Subsequently he disclosed his invention to other engineers in the Hazeltine laboratories. The president of the Hazeltine Corporation was so impressed with the operation of Wheeler's device that this company made arrangements to have a receiver made of the neutrodyne type by one of its licensees, Stromberg-Carlson Telephone Manufacturing Company, in Rochester, New York. This receiver embodied Wheeler's system of automatic

volume control, and it was successfully operated in the laboratories of the Hazeltine Corporation on August 10 and 11, 1926.

## 13.

On August 19, 1926, Wheeler disclosed his system of automatic volume control to a meeting of the engineers of the companies, which were at that time licensed by the Hazeltine Corporation.

## 14.

On July 7, 1927, Wheeler filed in the Patent Office his original application for a patent. On November 13, 1930, a division thereof was filed upon which the Wheeler patent 1,879,863, issued September 27, 1932. The application for the reissue of patent 1,879,863 was filed on September 26, 1934 and the reissue patent in suit, No. 19,744, was issued on October 29, 1935.

This Court has heretofore held that this reissue patent was a valid reissue and filed findings of fact and conclusions of law on that part of the case on April 17, 1939.

In the patent disclosure, Wheeler's automatic volume control system is described as applied to a tuned radio frequency amplifier receiver known many years prior to Wheeler, and comprising in succession at least one tuned circuit, a radio frequency amplifier tube, another tuning circuit, a detector (rectifier) to convert the radio frequency into audio-frequencies and an audio-frequency amplifier consisting of additional tubes and circuits.

The patent points out, however, that while such tuned radio frequency receivers have been referred to, the invention is generally applicable to radio receivers in wired radio and space radio systems, and that it has been found especially applicable to receivers of the super-heterodyne type.



## 15.

In the summer of 1927, Wheeler designed a radio receiver using his automatic control system for the Howard Radio Company of Chicago, another licensee of the Hazeltine Corporation. This receiver was unusually elaborate in every respect and was priced at several thousand dollars. Approximately six of these receivers were built commercially.

## 16.

Wheeler disclosed his automatic volume control system to the engineers of the radio industry at a meeting of the Institute of Radio Engineers, held in New York on November 2, 1927, and his paper was published in the proceedings of this Institute for January of 1928.

## 17.

In the summer of 1929, Wheeler designed a receiver for the Philadelphia Storage Battery Company, using his diode automatic volume control system. This Philco model 95 receiver was sold in large quantities and was unusually successful although priced higher than most sets of the time. Its operation was noticeably different from other sets because it was free from "blasting" and "fading". Its success was attributed to the automatic volume control system that it employed.

The Philadelphia Storage Battery Company acquired the Transitone Automobile Radio Corporation, which had unsuccessfully tried to market an automobile set. Its lack of success was due to the fact that a phenomenon similar to "fading" is particularly bad in automobile sets. A new set was designed using Wheeler's diode automatic volume control and was immediately successful.

The Philadelphia Storage Battery Company has continued to use the Wheeler automatic volume control system in its radio receivers ever since 1929. During this

time it has investigated all other available systems and has concluded that the Wheeler system with its diode rectifier is superior to all other systems. It is licensed by Radio Corporation of America as well as by Hazeltine Corporation.

## 18.

Wheeler's system of automatic volume control using a diode instead of a triode was not immediately adopted by the manufacturers and prior to Wheeler's suggestion that a diode detector be used it would have been considered a backward step by radio engineers because it sacrificed the amplification of the triode detector. The Wheeler system departed from the ordinary basis of engineering judgment and the ordinary engineer would have rejected it if suggested in 1925.

However, in recent years all of the substantial manufacturers of radio receiving apparatus in the United States, except the Defendant, are now using the Wheeler system under license. This system has continued to give satisfactory results. Wheeler's invention marks a distinct advance in the art and it has solved a practical difficulty in radio receiving equipment which is of great benefit to the public.

## 19.

In considering the prior art, the following patents have been referred to:

Affel .....	1,574,780	Simonds .....	1,914,219
Evans .....	1,736,852	Carter .....	1,739,351
Falknor .....	1,698,014	Evans .....	1,869,323
Friis .....	1,675,848	Armstrong ....	1,716,573
Ohl .....	1,772,517	Heising .....	1,687,245
Affel .....	1,677,224	Schelling .....	1,836,556
DeBelleseize ..	1,867,139	Slepian .....	1,455,768
Bruce .....	1,778,750		

## 20.

The system of automatic volume control disclosed in Wheeler's patent is not disclosed in or anticipated by any of the foregoing patents or in any publication. The nearest approximation to Wheeler is the disclosure of the Evans patents 1,736,852 and 1,869,323. In the Evans disclosure the direct current potential for biasing the amplifier grid is not as in Wheeler produced directly from the amplified and rectified signal but is derived from a source of energy in the plate circuit of a triode rectifier and the amount of potential derived from that source is controlled by applying the amplified modulated signal to the grid circuit of the triode rectifier. The control potential in the Evans arrangement is critically dependent upon the adjustment of the B battery and the C battery of the triode rectifier and, because the triode rectifier has a non-linear characteristic in the Evans arrangement, impressing the modulated carrier on the non-linear triode rectifier causes the direct current biasing potential and hence the automatic volume control to be affected by the degree of modulation of the signal; and the system therefore impairs the desired contrast of the signal.

## 21.

It is true that Wheeler's patent is for new combinations of electrical elements individually old but his system produces in a broadcast receiver automatic volume control in a new and better way. The original Wheeler patent (not the reissue) has been in litigation in the following cases: *Hazeltime Corporation v. Abrams* (D. C. E. D. N. Y.) 7 F. Supp. 908; *Hazeltime Corporation v. R. E. B. Service* (D. C. E. D. N. Y.) 8 F. Supp. 100; *Hazeltime Corporation v. Abrams*, 79 F. (2d) 329, (C. C. A. 2). I have considered these opinions in connection with the record made in this case, but have concluded that on



the record made in this case I cannot come to the same conclusion that these other courts reached.

## 22.

After giving due consideration to the prior art I am forced to conclude that the Wheeler system marks a new and useful improvement in the radio art requiring an exercise of inventive genius and that no mere mechanic skilled in this art, as it existed in 1925, would have been able to have developed it.

## 23.

Defendant's receivers follow the teachings of the Wheeler patent beyond the teachings of the Evans patents. In the defendant's receivers and in the Wheeler patent the control potential is created from the amplified signal itself without the interposition of any extraneous electromotive force. The result of this is that the control potential is maintained directly proportional to the energy of the amplified signal itself. This is desirable in an automatic volume control system. In the Evans patents, on the contrary, the amplified signal is used to control the electromotive force of an extraneous battery and to make the control potential out of that. In Evans there is the balancing of one battery against another in order to determine the control potential; in the Wheeler system and the defendant's receivers the potential for automatic volume control is independent of the characteristics of any particular diode tube. In Evans the automatic volume control potential is dependent upon the characteristics of the particular triode tube used.

## 24.

After the decision of Judge Galston on the original Wheeler patent 1,879,863, the plaintiff, Hazeltine Corporation, promptly asserted that patent against others, and also, as soon as the re-issue patent was granted

promptly asserted that patent against others, and has continuously asserted it. None of those cases has actually been tried except the R. C. A. case which was settled before decision, but this was through no neglect on the part of the plaintiff in asserting the rights which it here asserts against the Detrola Company, namely those based on claim 1 among others, but was due to the fact those cases were settled.

#### CONCLUSIONS OF LAW

##### 1.

Hazeltine Corporation now owns and has owned ever since the issuance of United States Letters Patent Reissue 19,744 the entire right, title and interest thereto and the right to recover for any infringement thereof. Said patent was duly issued October 29, 1935, on an application duly filed September 26, 1934 for reissue of original Letters Patent 1,879,863. Claims 2, 3, and 5, of said reissue patent are identical respectively with claims 2, 3, and 11 of said original patent 1,879,863 and plaintiff may recover for all infringements of those claims from the date of the grant of the original patent, namely September 7, 1932.

##### 2.


The Wheeler diode system of automatic volume control as described and claimed in Reissue Patent 19,744 was new on January 2, 1926. Wheeler was the first, sole and original inventor thereof. Said system is an invention and is patentable.

##### 3.

The fact that the Wheeler system of automatic volume control is different from any other system of automatic volume control, the fact that the diode used by Wheeler had not been in use in radio receivers for many years and previously had been rejected in favor of the triode, the fact that the diode had to be modified to accomplish

Wheeler's purpose by operating it at a high potential and connecting a high resistance across its electrodes, the fact that the diode after modification gave a new and improved result, the fact that other engineers and scientists working on the problem did not arrive at Wheeler's solution, the fact that the systems devised by others had defects that made them less satisfactory than Wheeler's, the fact that these other systems were devised by engineers in the foremost engineering and research groups, the fact that practicing engineers skilled in the art of radio receiver manufacture did not know of any successful automatic volume control system at the time of Wheeler's invention in December, 1925, the fact that Wheeler's system was at first regarded as a backward step by other engineers and manufacturers and later proved to be the best system, the fact that engineering laboratories and engineers at first recommended and manufacturers at first preferred to use other systems but finally adopted the Wheeler system after the others were found unsatisfactory, the fact that practically all receivers today that use any form of automatic volume control use the Wheeler system, the fact that the Wheeler system has gradually supplanted all others, the fact that defendant is licensed to use the other systems that were devised and nonetheless prefer the Wheeler system, the fact that the majority of other manufacturers are licensed to use the other systems that were devised but nonetheless prefer to use the Wheeler system, all constitute evidence showing that what Wheeler did amounted to invention.

"A new combination of elements old in themselves but which produce a new and useful result, or any diversity of arrangement of old things which introduces a new function, or a new and useful method of performing the old function in





a new way supports patentability." *Forestek Plating Etc. Co. v. Knapp Monarch Company*, (C.C.A. 6) 106 F. (2d) 554, 557.

Also see: *Bingham Company v. Ware* (C.C.A. 6) 46 F. (2d) 33; *France Manufacturing Company v. Jefferson Electric Company* (C.C.A. 6) 106 F. (2d) 605; *Cleveland Trust Company v. Scriber-Schroth* (C.C.A. 6) 92 F. (2d) 330; *National Battery Company v. Richardson Company* (C.C.A. 6) 63 F. (2d) 289; *Diamond Rubber Company v. Consolidated Tire Company*, 220 U.S. 428.

4.

Reissue Patent 19,744 is good and valid in law as to all the claims thereof.

5.

Detrola radio receivers, Models 175 and 178 embody the invention described and claimed in Wheeler Reissue Patent 19,744, particularly claims 1, 2, 3, 4, 5, 9, 10, 11, 12 and 13 thereof. Model 175 additionally embodies the invention claimed in claims 6 and 7 of said Reissue Patent.

6.

Detrola Radio and Television Corporation has infringed upon the rights of plaintiff Hazeltine Corporation under Reissue Patent 19,744 by manufacturing, selling and using radio receivers Models 175 and 178.

7.

Hazeltine Corporation is entitled to an injunction as prayed for.

8.

Hazeltine Corporation is entitled to an accounting as prayed for.

9.

Hazeltine Corporation is entitled to costs and disbursements, including stenographic service.

Dec. 26, 1939.

Arthur F. Lederle.

## INTERLOCUTORY JUDGMENT

(Filed Jan. 23, 1940)

This cause came on to be heard at this term and was argued by counsel and upon consideration thereof this Court specially found the facts and separately stated its conclusions of law thereon and directed the entry of appropriate judgment, and, in accordance therewith, It is Ordered, Adjudged and Decreed as follows:

1. That Hazeltine Corporation now owns and has owned ever since the issuance of United States Letters Patent Reissue 19,744 and ever since the issuance of United States Letters Patent 1,879,863 the entire right, title and interest in and to said Letters Patent and the right to recover for any infringement thereof.

2. That said United States Letters Patent Reissue 19,744 are good and valid in law as to claims 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12 and 13 thereof.

3. That defendant, Detrola Radio & Television Corporation, has infringed upon the rights of plaintiff, Hazeltine Corporation, under Reissue Patent 19,744 by manufacturing, selling and using radio receivers Models 175 and 178. Said models embody the invention described and claimed in claims 1, 2, 3, 4, 5, 9, 10, 11, 12 and 13 of said Reissue Patent 19,744, and Model 175 additionally embodies the invention claimed in claims 6 and 7 of said Reissue Patent.

4. That a perpetual injunction issue out of and under the seal of this Court directed to defendant, Detrola Radio & Television Corporation, and to each of its of-

officers, agents, servants, employees and attorneys, enjoining and restraining them and each of them from directly or indirectly making using or selling, causing to be made, used or sold, or offering to make, use or sell radio receivers Models 175 or 178 or other apparatus embodying or employing the invention and improvements of said claims 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12 and 13 of United States Letters Patent Reissue 19,744 or any substantial material or vital part or parts thereof and from infringing upon or contributing to the infringement or encouraging or inducing or aiding the infringement of or threatening to infringe any of said claims in any manner whatsoever.

5. The Court hereby retains jurisdiction to take evidence relating to, and preliminarily to determine, whether plaintiff, Hazeltine Corporation, has given such notice as is required by U.S.C. Title 35, Section 49 and thereupon to determine the period for which plaintiff is entitled to recover profits and damages from defendant, Detrola Radio & Television Corporation.

And the Court shall hereafter take and state for said period an account of the profits, gains and advantages which defendant has derived, received, earned or made or which it shall derive, receive, earn or make by reason of the aforesaid or any other infringement of said claims of said Reissue Letters Patent and shall assess for said period any and all damages plaintiff has sustained by reason of the aforesaid or any infringement of said claims.

And the defendant and its officers, directors, attorneys, servants, agents, workmen and employees are hereby directed and required to attend before the Court from time



to time as required and to produce such apparatus, books, documents and papers and to submit to examination, oral or otherwise.

6. That plaintiff recover of defendant profits and damages in such amounts as may be found by the Court.

7. That plaintiff recover its costs and disbursements, including stenographic service; that said costs and disbursements be taxed forthwith and paid to plaintiff without awaiting the outcome of said accounting proceedings; and that disposition of the costs of the accounting herein ordered shall await the further order of the Court.

Approved and entry directed:

Arthur F. Lederle,  
United States District Judge.

Approved as to form:

Pennie, Davis, Marvin & Edmonds,  
by R. M. Adams.  
Counsel for Plaintiff.

Whittemore, Hulbert & Belknap,  
by Arthur C. Beaumont,  
Attorneys for Plaintiff,  
3053 Penobscot Building,  
Detroit, Michigan.

Darby & Darby, by Floyd H. Crews,  
Counsel for Defendant.

Ellman & Rosin,  
Attorney for Defendant,  
1041 Penobscot Building,  
Detroit, Michigan.

Dated: Jan. 23, 1940.

**ORDER**

(Filed January 27, 1940)

This matter having come on to be heard on defendant's application for a stay of injunction and accounting herein,

It is hereby ORDERED that the injunction and accounting herein be stayed, pending appeal herein, provided that defendant file with the Court, on or before February 1st, 1940, a bond with good and sufficient security to be approved by the Court in the amount of Twenty-five Thousand Dollars (\$25,000.00), payable to plaintiff, herein on account of any damages, profits, costs or other recovery which plaintiff may at any time hereinafter be entitled to recover from defendant in this suit.

And further provided that defendant thereafter, during the pendency of said appeal, file with the Clerk of the Court, on or before the 25th day of each month, a statement under oath of an officer of defendant, giving the Model numbers and the net sales prices of all radio receivers sold by defendant during the preceding calendar month embodying automatic volume control in any form, and pay into the Clerk of the Court at the time of filing each of said statements, an amount of cash equal to one and one-half percent ( $1\frac{1}{2}$ ) of the aggregate net sales price of such radio receivers.

And provided further that defendant promptly perfect and diligently prosecute its appeal in this case.

And it is further ORDERED that if the defendant shall be successful in its appeal, and the bill of complaint herein be dismissed, said bond and cash shall thereupon be released to defendant.

Arthur F. Lederle,

United States District Judge.

Dated: January 27, 1940.

Approved as to form:

Whittemore, Hulbert & Belknap,

By Arthur C. Beaumont.

Attorneys for Plaintiff.

Ellman & Rosin,

By Henry P. Rosin.

Attorneys for Defendant.



**SUPERSEDEAS BOND ON APPEAL**

(Filed Feb. 1, 1940)

**Know All Men By These Presents:**

That we, the Detrola Radio and Television Corporation, a corporation, (now known as Detrola Corporation) as principal, and the Fidelity and Deposit Company of Maryland, a corporation, as surety, are held and firmly bound unto Hazeltine Corporation, in the full sum of Twenty-five thousand (\$25,000.00) dollars to be paid to the said Hazeltine Corporation, its successors and assigns, for which payment well and truly to be made we bind ourselves, our successors and assigns, firmly by these presents.

Sealed with our seals and dated this 1st day of February, 1940.

Whereas, on the 27th day of January, 1940, in the District Court of the United States for the Eastern District of Michigan, Southern Division, in a suit pending in said Court wherein Hazeltine Corporation was plaintiff and the Detrola Radio and Television Corporation, a corporation, (now known as Detrola Corporation) was defendant, said cause being No. 8337, an order was entered which, among other things, provided that the injunction and accounting herein ordered and decreed by interlocutory judgment heretofore entered be stayed pending appeal, provided that the defendant, Detrola Radio and Television Corporation, a corporation (now known as Detrola Corporation) file with the Court on or before February 1st, 1940, a bond with good and sufficient security to be approved by the Court in the amount of Twenty-Five thousand (\$25,000.00) dollars payable to plaintiff herein on account of any damages, profits,

costs or other recovery which plaintiff may at any time hereinafter be entitled to recover from defendant in this suit.

Now Therefore, the condition of this obligation is such that if the said Detrola Radio and Television Corporation, a corporation (now known as Detrola Corporation) shall prosecute said appeal to effect and, if it fail to make its plea good, shall answer any damages, profits, costs or other recovery which Hazeltine Corporation may at any time hereinafter be entitled to recover from Detrola Corporation by reason of this suit, then the above obligation be void; else to remain in full force and effect.

Detrola Radio and Television Corp.  
By (Sgd.) Henry P. Rosin,  
Its Secretary.

Fidelity & Deposit Co. of Maryland,  
By (Sgd) Harold C. Megreen,  
Its .....

The within bond is hereby approved this 1st day of February, 1940.

(Sgd.) Arthur F. Lederle,  
District Judge.  
2:58 P.M.  
Feb. 1, 1940.

**NOTICE OF APPEAL TO CIRCUIT COURT OF  
APPEALS UNDER RULE 73 (b)**

(Filed January 25, 1940)

Notice is hereby given that Detrola Radio & Television Corporation, defendant above-named, hereby appeals to the Circuit Court of Appeals for the Sixth Circuit from the interlocutory judgment entered in this action on

Ellman & Rosin,  
Attorney for Appellant,  
Detrola Radio and Television Corporation,  
Penobscot Building,  
Detroit, Michigan.

Dated: Jan. 25, 1940.



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